SYNERGY BETWEEN DENSITY AND ENERGY FOR BUILDING RETROFITS IN AMSTERDAM NIEUW-WEST

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MIGUEL ANGEL PELUFFO NAVARRO
4517830

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Name:	*Miguel Angel Peluffo Navarro* *4517830*
Tutors:	*MSc. Siebe Broersma*
	Dr.ing MSc. Thaleia Konstantinou
Examinar:	*Dr. Ad Straub*

SUMMARY

The thesis explores the necessity of change for the building stock of Amsterdam driven by the cities climate and densification targets, to develop a design of a retrofit for a building typology that maximizes the areas ability to reach these objectives. The area analysed for the retrofit design was a defined region in Amsterdam Nieuw-west, a current hotbed of developments that aim to regenerate the urban environment. The first demand explored is the need to reduce energy consumption in a building stock primarily made up of post-war buildings to achieve the drastic C02 reductions targets; a necessity which applies to all existing pre-energy-regulation buildings. Secondly, the demand to densify the city, as the population of Amsterdam continues to grow at a constant rate, fuelling the demand for accommodation and leaving it unmet by supply. The thesis sought to organize and quantify both these needs to identify a building typology that provided the best opportunity for retrofitting for both energy-saving and densification, which formulated the following research question:

How can the design of a retrofit measure offer integrated solutions to energy reduction and densification for a suitable residential building typology in the housing stock of Nieuw-West Amsterdam?

The first part of the research question required identifying the suitable building typology, which was done by collecting available data to categorize and quantify the characteristics of the building typologies present in the area, including their energy demand, the ownership status, type of roof, etc. Together with densification strategies and benchmark energy-saving measures for each building typology a suitable typology approach was developed which identified the 1950's Portiekflat, owned by social housing corporations, as the typology to base the retrofit design on, using top-up as the main densification strategy and replace and wrap principles for the energy aspect of the retrofit. Moreover, the final results for the most suitable typology showed an estimated C02 emission reduction of 19200 tons and an added capacity of 31900m2, which represents a potential C02 emission reduction of 5.8% and 2.5% increase in densification of the whole existing building stock in the area.

The second part focuses on systematically formulating the design of the retrofit measure to understand the central design decisions for choosing different design solutions to form an overall design strategy. Together with the literature results, the main design aspects of the retrofit measure are identified that serve as elements of the design strategy. These include energy performance, accessibility, structure, and housing quality, to which individual approaches are developed for the widespread application of the building typology together with the packaged decision paths that lead to them. The resulting combinations of approaches provide the design strategy which integrates the design aspects of the retrofit measure together and provides the basis for the final retrofit design. At this stage, the design explores the technical solutions of the chosen design strategy for a case-study building, including the application of retrofit measures, construction, and the building services. However, the primary relevance and answer to the research question is provided by the design process, manifested by three final products, the retrofit for energy-reduction and topping up the toolbox, the design decision tool and design strategy brief, which provides the different integrations between design aspects given the design decisions. In conclusion, the final research at its core aims to offer a more significant incentive to social housing corporations by aligning Amsterdam's need to densify with the need to energy-retrofit. In other words, densification can be used as fuel to power and accelerate an almost stagnant energy-retrofit rate which is missing the opportunity to tap into huge energy-saving potentials.

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1. RESEARCH FRAMEWORK

BACKGROUND

Amsterdam is in the process of transitioning towards a sustainable energy future, moving away from fossil fuel energy and towards renewable energy and energy efficient solutions, in order to drastically reduce and eliminate carbon emission. This process is empowered through targets and goals that have been set on a European wide level, namely the EU2020[1] targets and the eventual 2050[2] targets, which have been embraced by the city Amsterdam. However, the transition requires a strategy to direct all the relevant developments, especially within the built environment, towards achieving these goals. The City-zen project aims to create this strategy in the form a roadmap for cities like Amsterdam, that will allow a successful transition towards a sustainable future, by providing a theoretical framework to create urban energy master plans. The project finds itself in its initial stages and is primarily on deriving the framework by focussing on Amsterdam and so far a few guiding principles have been outlined, including retrofitting to tap into the huge energy-saving potential of the existing building stock.

The built environment of Amsterdam, plays an important role in enabling a successful energy transition to accomplish our energy goals, as it accounts for 40 % of the energy sector and 10% of carbon emission in Europe. The residential stock of buildings provides a critical challenge and opportunity for reducing energy consumption and C02 emission as it accounts for roughly 60% of the consumption within the building stock. New construction adds at most 1% a year to the building stock, the remaining stock consisting of 70% of buildings older than 30 years and of those buildings 35% are over 50 years. Given such a large quantity of existing buildings are likely to remain over the next 50 years with and unsatisfactory energy performance, one of the greatest energy-saving potential lies with retrofitting rather than new-builds.

1 Target endorsed by European Commission to reduce greenhouse gas emission by 20% compared to 1990 levels, increase the share of renewable energy of the energy sector by 20% and improve energy efficiency by 20%.

2 The 2050 target aims to reduce C02 emissions by 80% compared to 1990 levels.

Furthermore, the need for the implementation of retrofit measures on the building stock of Amsterdam is only one factor in the overall vision for Amsterdam. The current housing capacity of the city is in need of expansion for the purposes of accommodating a growing population; with a current population of around 830 000 the city is expected reach 1 million inhabitants by 2040, fuelling a growing housing crisis. The historic response to this issue has been to expand the city, which resulted in a decrease of density, however this approach is no longer desired. A report by the municipality titled 'Structuurvistie 2040 Amsterdam' (Structure Plan 2040 Amsterdam), outlines a 2040 vision for the city with an emphasis on competitiveness and quality of life, stating six tasks that need to be tackled with the first one being the need to densify (Amsterdam, 2011). Efforts by the municipality are already underway, with a planned 50 000 new dwellings within to be built by 2025 (Amsterdam, 2016). Nevertheless, more dwelling will be needed to keep up with projections and avoid a potential crisis. Measures to tackle this issue will unequivocally mean greater densification of the urban environment of Amsterdam. There is no doubt that a large part of the solutions lies in constructing new housing developments, but given the scarcity of land in the Netherlands and its urban environment, can a retrofit also provide solutions to adding housing capacity that align itself to the overall densification strategy of Amsterdam?

PROBLEM STATEMENT

Looking at the big picture of the existing building stock in Amsterdam, it is evident that there are two urgencies that will require certain modification in the form of retrofit. Firstly, lowering the energy consumption to make the stock more energy efficient and, secondly, is densifying to increase Amsterdam's housing capacity to accommodate a growing population. With current pressures to increase the low energy-retrofit rates in Europe and the Netherlands, a top-down approach can be an appropriate method of identifying the buildings or typologies that most require retrofitting. Therefore, being able to specifically develop measures that maximize the progress towards energy reduction and densification in Amsterdam.

OBJECTIVE

The main objective of this research is to organize and quantify the need to energy retrofit and densify within the residential building stock of Amsterdam Nieuw-West, in order to develop a design of a retrofit measure for a suitable residential typology that provides integrated solutions to both these urban requirements.

Final Products

The final product of this research is the design of a retrofit measure using a case-study building of the most suitable typology in terms of energy-savings and densification potential in the residential building stock. In order to achieve this final product other products, have to be done before and are defined as follows:

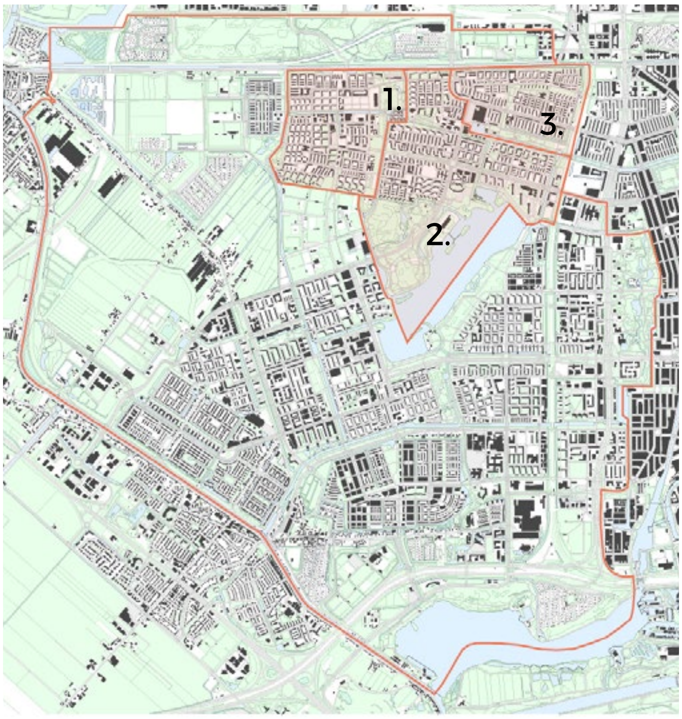
1. A Database of Typologies – the compilation of residential typologies of a defined area, in which building characteristics and relevant information is organized and sorted to help source the analyses conducted in the research project.

1. A Retrofit Toolbox – organized retrofit measures and strategies that provide energy-reduction and densification solutions to be applied on an urban and building scale.

Boundary Conditions

1. Energy Retrofits – Within the context of this research energy retrofit measures are investigated according to a minimum benchmark energy savings of 60%, in order to focus on deep energy retrofits rather than lighter measures.

2. Densification measures – Densification refers to the process of adding more housing capacity in a certain area. Moreover, in terms of measures that enable this process within built environment of the defined area, only measures that apply through the process of retrofitting will be explored as the aim of the research is to find overlaps between measures that reduce energy demand and add more housing capacity.



Neighbourhood Areas: 1. Geuzenveld 2. Slotermeer-Zuidwest 3. Slotermeer-Noordoost

Figure 1.1: Map of Nieuw-West Amsterdam showing the research area (shaded in red)

3. Area Constrain – The research area for the residential typologies will be constraint to Amsterdam Nieuw-West, specifically the 5 neighbourhood areas illustrated in Figure 1.1. The area of Nieuw-West was chosen as it is currently the area being investigated in the City-zen project. However due to limited time in this research project the area was further narrowed down to the 5 areas shown. This area was chosen as it provides a very diverse range of housing typologies built between 1946 and today relative to the rest of the district.

RESEARCH QUESTION

How can the design of a retrofit measure provide integrated solutions to energy reduction and densification for a suitable residential building typology in Amsterdam Nieuw-West?

Sub-Questions

Literature Review:

1. What is the current state of energy retrofitting as a means of achieving the climate targets?
2. What are the present and future energy standards for new-built and retrofitted building?
3. What are the current developments in the area in regards to densification and energy retrofitting?

Retrofit Toolbox:

4. What type of retrofit measures and strategies exist for reducing the energy demand of housing?
5. What type of strategies exist for densification of the urban environment?
6. How can densification strategies be applied on the existing residential stock of Amsterdam Nieuw-West?
7. What is the criteria for implementing the densification strategy?

Context Analysis:

8. What is the residential typology of buildings in Amsterdam Nieuw-West and what are their specific characteristics in terms of energy demand, C02 emissions, stakeholders, construction and age?

Suitable Typology Approach

9. What defined criteria can be used to determine the suitability for the case study building?
10. What is the potential for densification through retrofitting in the area of Amsterdam Nieuw-West?
11. What is the potential for energy retrofitting in the area of Amsterdam Nieuw-West?
12. What typology has the most potential in terms of

energy-savings and densification?

Design:

13. What technical solutions and concepts are there for the retrofit design?
14. Does the integration of retrofit measures help the energy retrofit aspect?
15. What thermal insulation, thermal mass, glazing and air-tightness values are required to achieve the desired energy-savings?

RESEARCH APPROACH

The research consists of three main phases, a literature review and context analysis; an analysis of the potentials; and the design of a case study building.

Literature Review

The literature review is divided into three sub-sections, each using general literature and case study methods but with the aim of providing separate conclusions that will further the research project. The first section focusses on collecting a thorough understanding on the energy retrofit and densification measures and strategies, in order to provide design parameters and strategies to be used further on in the research project. In the second section a study on the energy standards in the Netherlands, with their equivalent definitions, and a general typological profile of the countries buildings stock will be conducted in order to provide benchmarks for retrofitting and the necessary information regarding the building typologies in terms of their definition, which will be vital for the purposes of categorizing the data in the Context Analysis step.

Context Analysis

This step will require relevant data collection of all the different residential typologies in the defined area. Relevant cartographic information will be crucial to process and catalogue the information in terms of all the important building characteristics of each typology and their equivalent energy demand. The energy demand of each building in the defined area will be catalogued from online resources available.

Analysis of Potential

This step aims to provide answers as to what typology and stakeholder is most suitable for the design of the retrofit measure. Furthermore, in this step the results from the literature review and the context analysis are brought together to analyse the energy-saving and densification potential in the defined area of Nieuw-West. Both these analyses are done on the defined area and thus it will be analysed in terms of residential building typology within the area. The energy savings potential of each typology will be judged on the quantity of units per typology and the benchmark savings that can be achieved, determined by the literature results. The densification potential, uses the strategies outlined in the literature study and their corresponding criteria to determine where and how more housing units can be added into the defined area.

The culmination of both analyses will aim to provide answers as to which typology has what potential for energy savings and densification, providing the basis for assessing different retrofit scenarios given the stakeholder profiles. The scenarios will be used as a tool to provide insights into the opportunities and limitations for retrofitting a certain building or typology, grounded primarily in the literature study results. Therefore, it will be possible to justify which typology or group of buildings is most suited for retrofitting given the defined criteria.

Research By Design

In the phase, a case study building will be selected that is a good representation of the analysis of the previous phase. The results from the literature study will be used to provide a design criteria to aid in the decision making process of design. A detailed survey of the case study will be conducted in order further investigate the spatial, structural and service arrangements of the building, providing a detailed overview of the existing constraints to which the retrofit measure will be tailored for. The design decision for the retrofit measure can thus be recorded using the design criteria to justify different measures used. Furthermore, the aid of a flowchart will allow for the decisions to justify the measures used and more importantly show how different retrofit measure for densification and energy can be integrated.

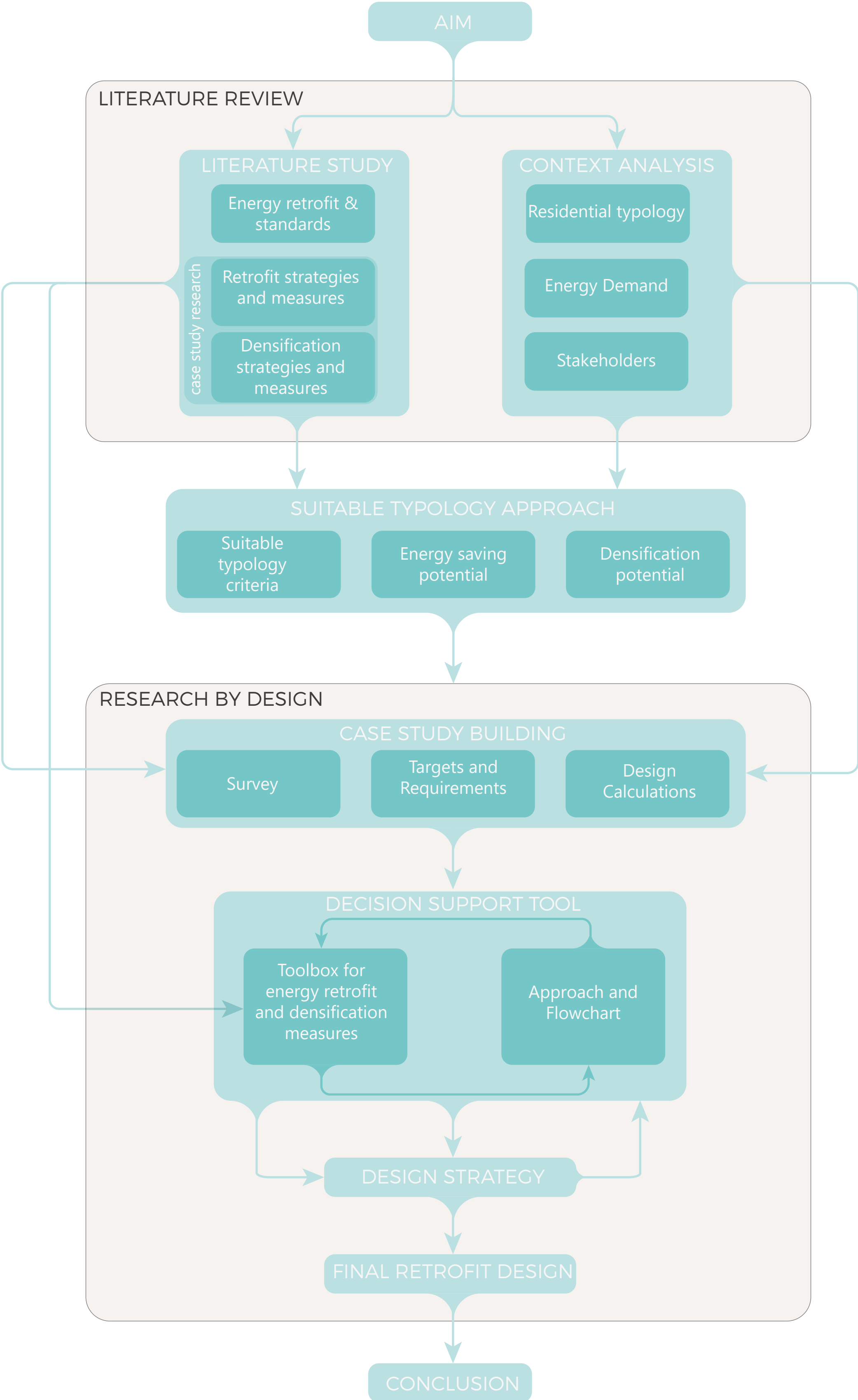


Figure 1.2 Research framework diagram

ENERGY RETROFITTING

Energy retrofitting refers to the refurbishment of a building to reduce its energy consumption and increase its energy efficiency. The total consumption comprising of end-uses including space heating and cooling demands, domestic hot water needs (DHW), cooking and electrical appliances; of which, space heating occupies the most significant shares, accounting up to 70% percent of the energy consumption across dwellings in Europe. The significance of retrofitting is growing as the current consumption levels of a predominantly energy-careless building stock creates a significant barrier for any of the EU's decarbonization targets. With the building industry accounting for around 40% of the total energy use in Europe with over half of that energy attributed to the residential sector, residential energy retrofit has become a priority for policymakers and planners to comply with mandated C02 targets. For example, in the Netherlands, the country with the largest proportion of energy certified buildings in Europe, the room for growth in improving the energy-performance in its housing stock is quite evident, with the majority of its stock build before 1975 labeled a D or worse as shown in Figure 2.1.

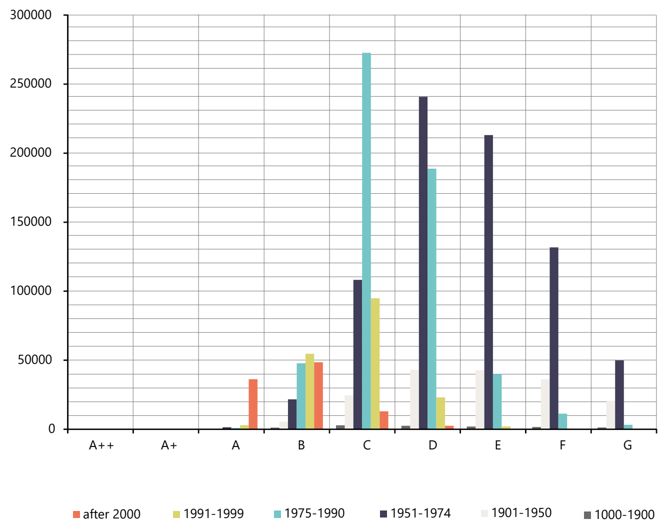


Figure 2.1:Energy labels for housing stock in the Netherlands (Agentschap NL, 2011)

Towards Deep Energy Retrofit

The absolute energy saving potential does not lie in future zero-energy buildings stock) but in the current existing building stock. A study by Ecofys, a renewable energy consultancy company, explored the economic implication a deep retrofit campaign to demonstrate the economic feasibility for single and multi-family homes across the European Union. The study concludes that prioritizing deep retrofitting of a building, reducing the energy demand between 60% and 90% compared to pre-retrofit levels, over shallow retrofits which provide savings between 30% and 50%, not only has the potential to be the favoured route from an ecological and economic perspective, but that adopting a 'shallow' retrofit solutions seriously risks missing our long-term energy targets. It further concludes that increased gas prices provide favourable market conditions for deep retrofits, in that energy-related costs per saved kilo-watt hour, were equal or lower than no-retrofit energy costs. A shallow retrofit approach simply misses the large energy saving potential, which directly translates into a loss of potential money saved and jobs created, despite its short-term advantage to deep retrofits (Hermelink & Muller, 2011).

This critical challenge is likewise addressed in the recast of the Energy Performance of Building Directive (EPBD), one of the leading EU policy instruments regarding energy performance of buildings, which primarily presents the notion of Nearly Zero-Energy Buildings (nZEB) but also states that the greater challenge is the refurbishment of the existing stock. Also, the Energy Efficiency Directive (EED) suggest that in regards to the building sector, the rate of building retrofits needs to be increased across Europe as it is the single biggest sector for energy-savings; encouraging the Member States to prepare long-term strategies for increasing investments for retrofits. It suggests that the strategic focus of cost-effective deep-retrofit to deliver a very high energy performance (BPIE, 2011).

REGULATIONS IN THE NETHERLANDS

The current regulations in the Netherlands regarding the energy performance of buildings in Europe follows the legislative groundwork set by the EPBD and EED. The recast EPBD of 2010 introduced the definition of nZEB - 'a building with very high energy performance where the nearly zero or very low amount of energy required should be extensively covered by renewable sources produced on-site or nearby.' It further states that all new buildings built after the 31st of December 2020 should be nZEB, with this requirement coming sooner for all new public buildings on the 31st of December 2018. It requires Member States (MS) to set out their own specific national definition of nZEB to eventually implement them for new-builds in 2020, leaving the approach and assessments of nZEBS up to each country.

In The Netherlands, the energy performance of buildings is expressed by the Energy Performance Coefficient (EPC), a non-dimensional number determined by the Dutch norm NE 7120. It was first introduced in 1995 to provide minimum standards energy efficiency standards in the building regulations. The method of determination uses the following considerations:

- Standard energy use for given function and climate condition
- Only the building related energy is valued in the calculation for the energy performance
- District heating availability
- Renewable energy
- Production of energy can take place inside or outside the building
- The net energy use is calculated on an annual basis

The resulting figure from the calculation is indexed alphabetically to form the energy label (See Figure 2.2) which forms part of the Energy Performance Certificate. With this in mind, a nZEB is determined when EPC = 0. Currently, Dutch regulations are moving towards an EPC 0 as all building built after 2015 had to have a mandatory score of 0.4, an improvement from the 0.6 score that buildings had to comply with from 2013. However, in terms of the oversight by the European Commission for nZEB definition for retrofitting, there are none provided, the directive only encourages Member State to develop policy addressing building retrofit to nZEB level. So far, only eight countries have set nZEB definitions for retrofits with Austria, Denmark and France among them.

Prescriptive technical norms relating to energy retrofits are provided by the Dutch Building Act (Bowbesluit).

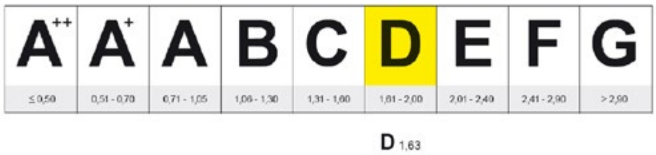


Figure 2.2: EPC Lables with corresponding index score. (Cohereno, 2013)

Within the document, two types of retrofit interventions are specified: deep and partial renovation. Deep renovations are considered to be anything above 25% of intervention on the existing building envelope, with anything below that percentage being classified as partial. The implications on the level of retrofit are the technical requirements prescribed by NEN 1068 for the different building components. Important to the thesis are the thermal resistance minimums for building elements and these are illustrated in Table 2.1, showing the differences between deep and partial retrofits (Cohereno, 2013).

The other important aspect to quality control in regards to energy in building retrofits and new builds

BUILDING ELEMENT	*PARTIAL RETROFIT*	*DEEP RETROFIT*
	(W/m²K)	
Ground Floor	0.40	0.29
Facade	0.77	0.22
Roof	0.50	0.17
Window	2.22	1.65
Door	2.22	1.65

Table 2.1: Thermal resistance for retrofits.

is air infiltration, determined by the air tightness of the construction. It is a crucial parameter that influences the energy performance of the building envelope, as the greater the envelope 'leaks' the greater the energy losses. However, as construction measures increase air tightness, considerations for the ventilation of the building become vital in order to maintain a good indoor air quality and avoid damaging condensation to the building envelope. The Dutch building act defines different classifications for the air infiltration which depends on the ventilation system the building employs and its volume, see table 2.2. The regulations show air-tightness at 10pa and it is measured using the door blower method; the results should correspond to the ones shown in Table 2.2.

Class	Ventilation System			
1	Natural Ventilation (A) - Natural Supply/ Mechanical Extraction (C)			
2	Mechancial Supply/Natural Outlet (B) - Mechanical Supply and Extraction (D)			
	Air Infiltration			
	Building Volume (m^3)	q_{v10} Maximum (dm^3/s)	q_{v10}/m^2 ($dm^3/s.m^2$)	q_{v10} Minimum (dm^3/s)
1	<250	100	1,00	30
	250-500	150	1,00	50
	>500	200	1,00	50
2	<250	50	0,60	-
	>250	80	0,40	-
3	<250	15	0,15	-
	>250	30	0,15	-

Table 2.2: Air infiltration regulations in the Netherlands. Praktijkboekbouwbesluit2012

ENERGY RETROFIT STRATEGIES

Trias Energetica and New Stepped Strategy

Trias Energetica has been the underlining strategy used for transitioning towards a more sustainable and energy efficient built environment since the 1980s and is formed as a logical environmentally conscious approach consisting of three steps, illustrated in Figure 2.3. Step one requires the reduction of energy demand using passive architectural measures; this then enables renewable energy technologies to be much more viable for installation, which forms the gist of step two. The last step involves the implementation of efficient fossil fuel technology to generate the remaining energy that cannot be covered by renewables. In practice, however, sustainable buildings in the Netherlands tend to lead with step three, efficient fossil fuel technology, due to the economic infeasibility of renewable technology covering a large part of the energy demand, especially when sub-optimal energy reductions are made in step one (AgentschapNL, 2013).

Based on this practical experience of the Trias Energictica model and lessons from the Cradle to Cradle philosophy, the New Stepped Strategy was developed adding an intermediary step into the approach which utilizes the waste streams of buildings, neighbourhoods, and cities. Essentially, before resulting to renewables in step two and after having reduced consumption, the reuse of waste heat, water and materials has to become a priority. The

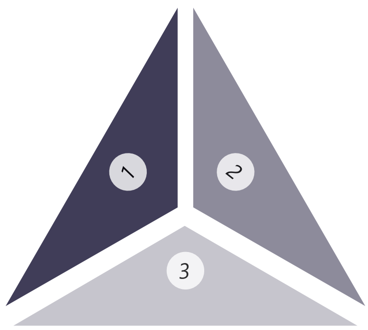


Figure 2.3: Trias Energiteca Diagram - 1. Reduce energy demand; 2. Use renewables to cover as much energy demand as possible; 3. Cover rest of demand with efficient us of fossil fuels

reuse of waste streams also enables a scalar approach between building, neighbourhood, district, and city (Tillie, et al., 2009).

Nevertheless, the all-important first step of reducing energy consumption provides the leeway on which these sustainable-transition approaches stand on making all other interventions feasible and logical. This crucial first step in regards to energy retrofits within the Trias Energetica approach necessitates the use of passive measures which exploit the design and properties of the building envelope within its local climate to either maximize or minimize heat loss thereby reducing energy demand. Additionally, the production and distribution energy across the building to achieve the necessary indoor temperature, provide hot water and electricity are comprised of active measures

Passive Measures

These measures follow design principles that make use of local climate, the existing building layout, and material properties to minimize energy demand. They can be characterised under three basic functions: heat protection, passive solar gain, overheating prevention.

Heat Protection

Heat refers to the flow of energy from high to low-temperature zones, a natural process which the building envelope has to prevent so that in winter, heat cannot escape from the inside to the outside, with the reverse principle in summer. The building envelope prevents this by increasing thermal resistance of its components, improving the airtightness and eliminating thermal bridges.

One of the most critical measures in retrofit projects is insulation, which improves thermal and acoustic properties of mostly opaque building components. Transparent components of the envelope need mainly to be replaced with multiple panes of glass with a small air cavity providing the vital thermal resistance.

Air tightness is the other crucial factor when improving the building envelope's energy performance because it reduces infiltration, the movement of air through leaks, cracks and or other accidental openings in the construction. In terms of energy, infiltration is a major cause of heat loss and even with present regulations, the leakage can contribute an additional 5-20kWh/m2/a in a moderate climate, degrading the overall effectiveness of insulation and jeopardizing the envelope to moisture entering its construction (BPIE, Europe's buildings under the microscope, 2011). However, in many old building air infiltrations is a main source of ventilating which preserves the indoor air comfort at a major energy cost. Therefore when improving the airtightness, especially to high standards, it is essential to couple it with a ventilation system, be it passive or mechanical. A mechanical ventilation system, especially ones with heat recovery, depend on good airtight construction or retrofit for their energy performance success (Konstantinou, 2014).

Passive Solar Gains

Solar gains are only desired during heating season and are utilised as a form of indirect gains which the overall building design influences by collecting, by means of southward facing glazing, storing, by exposing construction materials with high thermal capacity and distributing, through convective air currents in configuration with spatial arrangement, the energy within the building. In addition to passive gains, the building design can take advantage of daylight to reduce the need for electric lighting during the day and thus lower the overall energy demand.

Such benefits depend primarily on the amount of transparent or translucent elements in the building envelope, in conjunction with building orientation, shading, and reflectance from surrounding buildings and local weather condition. Important to note is that as windows are deemed a heat loss area in the thermal envelope, it is crucial to make sure that the indirect gains outweigh those losses during heating season (Richarz & Schulz, 2013).

Prevention of overheating

Avoiding overheating is crucial during the summer season to maintain an adequate thermal comfort of occupants. Like with indirect solar gains, the passive methods of prevention lie with the building design. Techniques including sun control, natural ventilation and exposure of materials with high thermal mass can all be employed to prevent overheating passively. The main passive method is the use of shading devices for south-facing glazing and openings, in which the choice is almost infinite and range from projecting eaves to simple blinds. The decision in many cases depends on architectural qualities as well as energy performance. The most effective shading devices are external rather than internal and depending on orientation, horizontal screens or vertical louvres might be more appropriate. South-facing façades benefit more from horizontal overhangs as the sun angle hits from a relatively higher angle and perpendicular to the façade face, while west and east facing façade benefit more from louvres that block lower angled sun-rays.

During high-temperature periods, it is essential to have airflows through the building that exchange the heated air with relatively cooler outdoor air. Using climatic forces, façade openings can allow for several types of natural ventilation, be it single-sided, cross or stack ventilation. There is a variability, as the airflow patterns that can be taken advantage of depend on prevailing weather conditions. Nevertheless, in moderate climates, natural ventilation can be relied on for most parts of the year and especially during summer.

Active measures

Passive measures cannot in themselves eliminate energy demand and require active measures to generate and distribute energy in the building to achieve modern indoor comfort levels, also known as building services. In this respect, they constitute an integral part of the retrofit strategy and even though this thesis is primarily focussed on passive measures, it is important to provide an overview of common building service measure. The source of energy for these active measures can vary from different types of renewables to fossil-fuel based to service the necessary heating, ventilation, lighting and electricity demands within a home. For building retrofits the upgrade of these building services to more efficient can result in significant energy reductions and especially the addition of renewables can lead to an energy neutral or even energy positive building.

Photovoltaic panels (PV) are a growing technology used to generate on-site electricity for the building. The common measure includes installing the panels on the roof, as they rely on exposure to sun, some roof types render the panels ineffective. For the north of Europe, the maximum output is achieved with panels at a 300 tilt facing southward. PV development has also led to panels being able to be integrated in the façade as a cladding skin, allowing for the possibility for a façade upgrade to produce and reduce energy, which, even though the PV output is not maximized due to the supposed 900 tilt of the façade, can offer pay-back advantages as the PV replace the need for standard cladding (Schittich, 2011).

The other type of solar-generated energy comes in the form of solar thermal panels, in which solar radiation is directly converted into heat energy that can be used for domestic hot water (DHW) demand. This system combined with a hot water storage system is an efficient solution for maximized energy reductions. The most efficient panels are evacuated solar heating collectors compared to the conventional flat plate type of collector.

Other forms of renewable heating sources include biomass and geothermal. Biomass is an organic substance, considered C02 neutral taking into account the whole lifecycle of the substance. It comes in the form of wood (pellets or chips), vegetable oil or biogas and can be used in fuel to burn for the heating system of the house. The other source, geothermal, a constant temperature source found deep underground, usually beyond 30m, where the temperature is around room temperature and by circulating water it is possible to transfer that energy to heat the building.

Fossil fuels might still be required even after passive and renewable measures have been exhausted in the retrofit strategy, especially when it comes to space heating. The most commonly found system in a residence is a boiler, which heats up water by either combustion or electrical resistance and then distributes it for space heating and

DHW demand. Modern boiler's efficiency has increased significantly in the last twenty years in terms how well the heat generated from combustion or resistance is transferred to the heating system, achieving up to 91% efficiency, meaning that the simple replacement of a boiler system can bring about energy reductions (Konstantinou, 2014). These reductions may be maximized by combining it with a heat pump, which are units purposed to transfer heat from a variety of sources ranging from high to low-grade energy, using a vapour compression refrigeration system or a refrigerant/sorbent pair. Typical heat sources include air, water, and ground, with air source systems being the easiest to install and requiring the least amount of space. Water base heat pumps are not as common as it requires a proximity to a water source, while ground-sourced pumps require laying pipes at 1 meter below the surface.

Mechanical ventilation becomes a vital active measure when an airtight construction is realized to supply sufficient fresh air to occupants. These systems can be coupled with a heat recovery unit, which exchanges heat from the incoming fresh air with outcoming warm extracted air at up to 85% efficiency, to help mitigate otherwise lost energy due to ventilation.

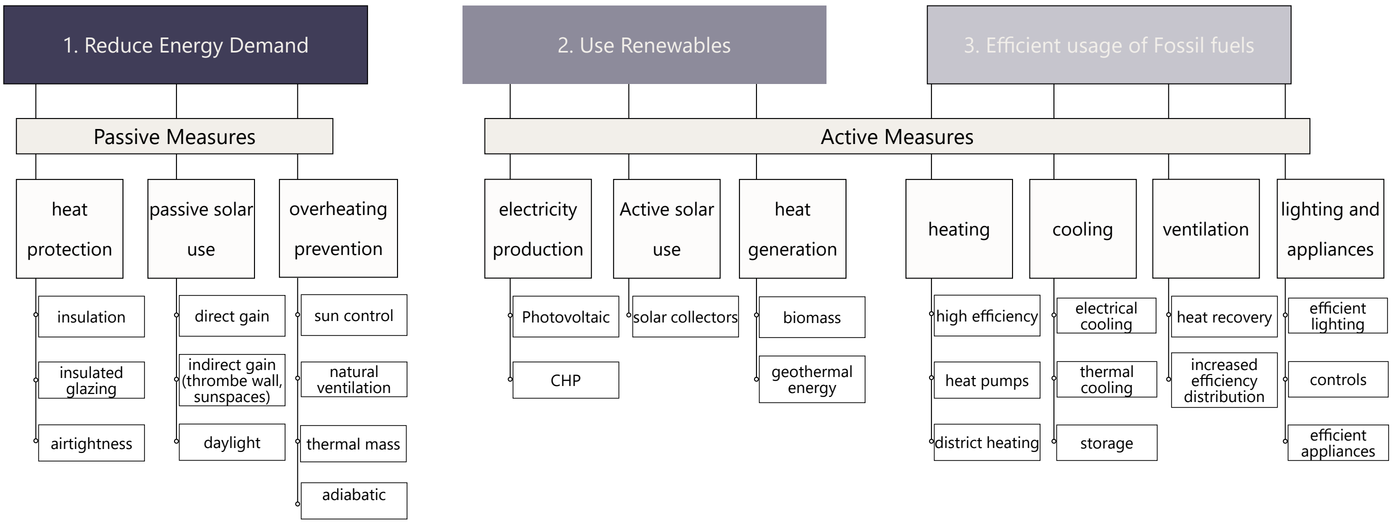


Figure 2.4: Summary of measures organized according to the Trias Energetica Model (Konstantinou, 2014)

BUILDING ENVELOPE STRATEGIES

The building envelope plays the most crucial role in a deep energy retrofit as the energy consumption of the building is directly related to it. Specifically, the building components, such as external wall, glazing, windows, balconies roof and ground floor, which make up the thermal envelope, the boundary between heated and unheated spaces. Building and thermal envelope may differ according to the design and function of the space, thus defining the thermal envelope becomes important for identifying where the heat losses occur and how they can be improved.

This section provides an overview of retrofit strategies, presented in Table 2.3, categorized under a common retrofit principle. It is important to note that these strategies are not mutually exclusive with one another , a retrofit design might use a combination, however, by categorizing the underlining principle it is possible to provide an overview and identify the benefits and limitations to each one (Konstantinou, 2014).

Replace

This strategy involves replacing the existing façade elements with new ones. This strategy can be applied to various building types, especially ones where the façade components are non-structural like a curtain wall. Vice versa, it not ideal for façade components which are structural, as the removal would incur relatively high costs due to the attentional structural attention required.

Add-in

In some cases the retrofit strategy involves improving the inner side of the envelope in order to leave the existing façade aesthetics untouched, which is a main priority in listed monument buildings with historical significance. A common intervention is the application of insulation on the inside of the façade, as well as cavity wall insulation, together with the replacement of windows.

Wrap-it

'Wrapping' consists of applying a second layer to the outside of the envelope including external insulation, the cladding of balconies or using a secondary façade. This strategy requires the existing envelope to bear the new layer, providing opportunities for gaining extra living space. The main benefit to this strategy is the tackling of thermal bridges, opportunities for a new appearance and easier installation as interventions are done on the outside.

Add-on

Similar to Wrap-it, Add-on is characterised by the addition of a new structure on the envelope, ranging from small intervention like new balconies to new buildings added on as an extension of the existing. Moreover, this strategy usually requires the use of the other strategies in order to significantly improve energy performance.

Cover-it

Some areas of buildings may be covered to create new internal spaces, effectively creating buffer zones to regulate between the existing envelope and external environment. The strategy depends mostly on existing layout of a building and cannot be treated as a generic solution due to this condition.

Evaluations of Strategies

The choice of a strategy is dependent on a variety of factors encountered during the retrofit design stage. Completed retrofits usually mix strategies not only to improve energy performance efficiently but also upgrade living standards, be it by increasing dwelling area, providing new spaces or improving internal comfort.

However, when judging the strategies solely, certain ones provide more significant advantages regarding energy-saving measures over others. In this regard, Add-In becomes the least viable as thermal breaks are more likely in junctions of the wall and floor slab, due to the thermal barrier line breaking in contact with structural members, which makes infiltration rates evermore harder to manage. Moreover, the reduced usable space caused by the intervention amplifies its impracticality which mainly reserves this approach for listed monument buildings with historical significance.

Strategically, Wrap-It solves the problem of thermal bridges as a whole new thermal barrier is offset running parallel around the existing envelope, with thermal break easier to accommodate for new balconies or other new structural components. This also means that infiltration rates can be controlled better making energy-savings much more likely. However, a sole wrap approach can lead a thick external envelope, especially when large thermal-resistance improvements are sought, which can hinder feasibility if outer space is unavailable. As a large portion of residences are constructed with a cavity wall, wrapping along with replacing can also provide a solution keeping the external envelope to a minimum thickness and thermal-break free. In this case the outer leaf is removed and an external insulation system with cladding is introduced to provide the needed thermal resistance.

As mentioned before, these strategies shouldn't be taken on their sole merit; an integrated retrofit design incorporates a range of measures which provide solutions to what the design briefs demand. Using them in combination offers optimal solutions between different refurbishment targets including energy-reduction. Replace and Wrap-It includes some of the most common measures used for energy-reduction, with Add-on providing some useful dwelling assets that mutually benefits energy-performance. Cover-it and Add-in are used for particular cases that depend on a building by building basis and require elements of the other three strategies for an integrated refurbishment strategy.

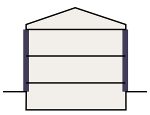
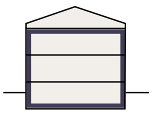
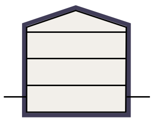
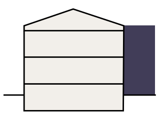
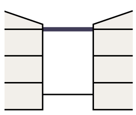
STRATEGY	*DESCRIPTION*	*INTERVENTION VARIATION*	*BENEFITS*	*LIMITATIONS*
Replace 	Existing building components removed and replaced.	• Whole facade can be replaced • Replacement of certain components	• New better performing components installed	• High installation costs • Impacts users
Add-in 	Improvement of thermal envelope from the inner-side	• Internal insulation • Cavity insulation • Box window	• Allows listed monuments to improve energy performance • Increases thermal resistance without affecting external facade aesthetics	• Critical junctions require special resolving of thermal bridges • Disturbance for users
Wrap 	Improvement of thermal envelope from the external side.	• External Insulation • Cladding of balconies • Second skin facade	• Solves thermal bridges • New appearance of facade with many cladding options • Minimal installation disturbances	• Cannot be used for monument buildings
Add-on 	Addition of new structure onto building envelope.	• Addition of small structures. E.g balconies • Addition of building extension • Addition of new storey	• New thermal barrier • Increase dwelling space • Thermal buffer • Functional benefits	• Structural limitation regarding existing condition. • Requires other strategies for the rest of the envelope
Cover-it 	Cover parts or entire internal and external courtyards.	• Heated and unheated areas of building can be covered	• Creates thermal buffer • Ventilation opportunities with stack-effect • Additional space	• Only applicable depending on existing layout of building • Risk of overheating • High costs

Table 2.3: Summary of building envelope strategies. (Konstantinou, 2014).

Retrofit measure toolbox

The strategies provide an overview of the main principles involved with retrofitting and are essentially a collection of categorized individual retrofit measures that specifically target a certain building element of the envelope. These strategies have been illustrated and evaluated against one another but it is important to offer the collection of retrofit measures that are available in order to assist with the eventual design of a retrofit for a specific building typology in Amsterdam Nieuw-West. Borrowing from 'Façade Refurbishment Toolbox' (Konstantinou, 2014), the toolbox matrix with the different retrofit measures for each building element, including external wall, window, balcony, roof and ground floor, is illustrated in its general term along with renewable energy systems, building services and possible spatial interventions possible with the upgrade of the building envelope.

Table 2.4 illustrates the matrix of retrofit measures given the building element they target, which will serve useful in the later stages of the thesis.

	BUILDING ENVELOPE					BUILDING SYSTEM	
	EXTERNAL WALL	*WINDOW*	*BALCONY*	*ROOF*	*GROUND FLOOR*	*HEATING*	*VENTILATION*
Retrofit measures	Cavity wall insulation	Upgrade windows	Insulate balcony slab	Leave pitched roof as unheated loft	Insulation on top of ground floor slab	Replace existing boiler to high efficiency boiler per dwelling	Natural inlet/ mechanical exhaust
	Internal insulation	Secondary glazing (single)	Remove balcony	Insulate on top of roof (warm roof)	Insulation below ground floor	Replace existing boiler to high efficiency boiler per block	Mechanical inlet/ natural exhaust
	Exterior Insulation and finishing system (EIFS)	Secondary glazing double	Balcony cladding - single glazing	Insulate below roof (cold roof)	Insulation below first floor slab - leave ground floor unheated	CHP installation	Mechanical ventilation
	Ventilated facade	Replace windows (double pane)	Balcony cladding - double glazing	Green roof		Heat pump	Mechanical ventilation system with heat recovery (MVHR)
	Timber-frame wall	Replace windows (triple pane)				Biomass boiler	
	Second facade with single glazing	Shading device installation					
	Second facade with double glazing						
RES	Building integrated photovoltaic			Photovoltaic		Solar collectors	
Spatial interventions	Additional space integrated in second facade	Shading fixed	Integrated balcony				
	Lift addition	Enlarged windows	New balcony	Additional floor		District heating	

Table 2.4: Envelope retrofit toolbox summary with measures (Konstantinou, 2014)

Lucellestraat Amsterdam

This case-study is located in Amsterdam's Bosleeuw district, built in 1940, it is a multifamily complex consisting of four connected blocks that form a courtyard and accommodates 600 dwelling. The retrofit of the complex is part of the larger regeneration of the urban area, which values the historical importance of the construction of the building. For this reason, the retrofit not only had to improve the energy performance but also restore its character to help invigorate the immediate urban surroundings.

The retrofit design incorporated an external insulation with finishing system (ceramic bricks), top-side roof insulation that wrapped the gables as well to avoid thermal bridges, under first floor insulation and replacement of single glazing units with double glazing (HR++). The building services included a mechanical ventilation upgrade and PV panels an energy source for some apartments, these are able to cover up to 25% of the new energy demand. With these measures it was possible to jump from a Label F to an A rating, representing a minimum of 60% energy reduction (Nieman, 2015)..

Figure 2.5: Image of Lucellestraat from main street view pre (image above) and post retrofit (image below).

		SUMMARY OF RETROFIT MEASURES
BUILDING ELEMENT	*EXISTING CONSTRUCTION*	*MEASURE*
External wall	Uninsulated cavity wall	External 50mm EPS insulation applied
Window	Single and double glazing	Double glazing (HR+) upgrade
Balcony		
Ground Floor	Uninsulated uninsulated	100mm Glass wool Insulation under first floor
Roof	Uninsulated wooden rafters	External 50mm EPS insulation applied
BUILDING SERVICES		
Heating	VR-boiler	HR-107 combi-boiler
Domestic Hot Water	Combitap VR	combitap HR
Ventilation	Natural	Mechanical
Energy	NA	PV (some apartments)

Table 2.5: Summary of retrofit case-study measures. (Nieman, 2015).

Siboldusstraat, Bolsward

A total renovation of 70 terrace houses in the area of Bolsward took place in which the complete outer envelope was renewed to provide high quality thermal resistance, which, together with innovative building systems such as air-heat pumps, thermal and PV panels, elevated the EPC performance of each dwelling to a score of A++ (Energy Index: 0.10-0.34). Extra precautions were taken to reduce air-infiltration rates with the completely new outer-leaf, so that the new ventilation system could provide optimal results. The existing radiators were connected to the new solar-thermal panels installed on the pitched roof that together with an air-heat pump helps recycle the energy across the house as well as for the use of hot water. Even the gas-connections were removed along with all the complementary appliances and 28 PV panels were given the opportunity absorb the latter's absences (Nieman, 2015)..

Figure 2.6: Image of Siboldustraat from street view pre (image above) and post retrofit (image below).

		SIBOLDUSSTRAAT, BOLSWARD
BUILDING ELEMENT	*EXISTING CONSTRUCTION*	*MEASURE*
External wall	Cavity wall with 60mm of insulation	Cavity wall insulation with high thermal resistance foil
Window	Single and double glazing	Double glazing (HR+) upgrade
Balcony		
Ground Floor	Uninsulated timber beams	300mm of thermoparels +60mm of hard insulation in crawl space
Roof	Pitched roof with 50mm insulation	135mm of insulation added
BUILDING SERVICES		
Heating	HR-107 combi-boiler	Air-heat pump
Domestic Hot Water (DHW)	combitap HR	Air-heat pump
Ventilation	Natural	Heat-recovery ventilation
Energy	NA	44.8m^2 of PV (west and east facing)

Table 2.6: Summary of retrofit case-study measures (Nieman, 2015).

Martin Campslaan, Rijswijk

The neighbourhood of South Steenvoorde in Rijswijk is comprises of six large multi-storey gallery blocks owned by a social housing cooperation, Woningcorporatie Rijswijk. These building were constructed in 1974, of which two were refurbished using the measures listed in Table 2.7, to extend its life by another 40 years and upgrading its energy performance to an average EPC B rating, up from an E. Relative to the other case-studies presented, the passive measures implemented were minimal, the key building element targeted were the roof and ground floor with new addition of insulation. In respect to the façade, much of the previous insulation was left, mostly the panels were replaced with new ones with better energy performance and glazing was replaced with high efficiency double glazing (Nieman, 2015)..

Figure 2.7: Image of Martin Campslaan from street view post retrofit.

		SUMMARY OF RETROFIT MEASURES
BUILDING ELEMENT	*EXISTING CONSTRUCTION*	*MEASURE*
External wall	Uninsulated cavity wall	-
Window	Single and double glazing	Double glazing (HR+) upgrade
Balcony	Gallery insulated with 20-50 mm of insulation panels	Gallery insulation upgraded to 50-80mm insulation panels
Ground Floor	Concrete slab on ground	85mm of wood fibre insulation applied on bottom of first floor
Roof	Uninsulated wooden rafters	80mm of hard insulation
BUILDING SERVICES		
Heating	HR100 boiler (collectively)	HR107 Furnance + HT individual
Domestic Hot Water (DHW)	Kitchen geyser	Intergas HRE 24/18 CW3
Ventilation	Natural suppy + mechanical extraction	Natural suppy + mechanical extraction
Energy	NA	332m2 (1.4m^2 per unit) PV (15° south facing)

Table 2.7: Summary of retrofit case-study measures (Nieman, 2015).

De Luttebrink, Enschede

Within this neighbourhood reside a cluster hobby home blocks in which three of these, totally 28 dwellings, were retrofitted to Passivhaus Standard, propelling it existing rating of E to an A++ in terms of EPC. As one of the most stringent standards, achieving Passivhaus required the complete removal of the outer-shell to allow for think layers of insulation that effectively wrapped the whole building together with and airtight layer. A mechanical ventilation system with heat recovery was installed which works systematically with the energy from the thermal panels on the roof.

The retrofit project managed to achieve the 0.6ach (air changes per hour) necessary for certification, a difficult task when refurbishing as air leaks are sometime hard to avoid between new and old construction. In addition to air seals and tapes, rubber spray between the new and old building elements was used to assure airtight construction (Nieman, 2015)..

Figure 2.6: Image of Siboldustraat from street view pre (image above) and post retrofit (image below).

		SUMMARY OF RETROFIT MEASURES
BUILDING ELEMENT	EXISTING CONSTRUCTION	MEASURE
External wall	Partially insulated facade	400mm outerwall insulation
Window	Single and double glazing	Triple glazing
Balcony		
Ground Floor	Uninsulated timber beams	180mm insulation under crawl space
Roof	Pitched roof with 50mm insulation	380mm outer-wall insulation
BUILDING SERVICES		
Heating	VR-boiler	HR-107 boiler
Domestic Hot Water (DHW)	geyzser	Combitap HR (HR-107 + solar-water boiler)
Ventilation	Natural	Mechanical ventilation with heat recovery
Energy		

Table 2.8: Summary of retrofit case-study measures (Nieman, 2015).

Summary Of Case Studies

The case studies presented each prioritize reducing the energy demand of the building demonstrating a whole range of specific retrofit solutions given the building typology and constraints, each achieving a different energy performance target (summarized in Table 2.9). However, their retrofit strategy is very similar, relying on measures that wrap insulation around the external side of the thermal envelope as well as complete replacement of single glazing with at least double glazing. The most ambitious case-study, the buildings of De Luttebrink in Enschede, demonstrates this strategy most authentically as a rigorous optimization of the thermal envelope was required to achieve the Passivhaus standard. In this case adding a 400mm external layer of insulation (200mm in crawl space of ground floor) bound to the old construction in an airtight seal. When trying to achieve such airtight construction, the use of mechanical ventilation becomes mandatory as reliance on previous air-leaks in the construction is no longer an option for ventilating.

In the retrofitting of these homes an important parameter provided by the existing constraints is the form factor of the building, which is ratio between the heated used surface area and the area of the thermal envelope. The lower the ratio, in other words if the if the heated surface area is greater relative to the thermal envelope area, the more efficient the thermal envelope is at retaining the energy and thus less insulation is required to achieve required performance. Therefore, different building typologies will be able to perform better or worse with the same insulation. This is certainly the case for the case-study in Rijswijk, where not much extra insulation was added but the addition of roof and replacement of single glazing to double had a big impact on the final energy reduction.

CASE STUDY	*ENERGY PERFORMANCE*	
	Pre-Retrofit Epc	Pre-Retrofit Epc
Lucellestraat Amsterdam	2.42 - 3.22	0.66 - 1.12
	F-G	A++,A-B
Siboldusstraat, Bolsward	1.37 - 1.72	0.10 - 0.34
	C-D	A++
Martin Campslaan, Rijswijk	1.50 - 2.35	1.01 - 1.23
	C-E	A-B
De Luttebrink, Enschede	2.23	0.48
	E	A++

Table 2.9: Summary of retofit case-studies.

DENSIFICATION

Densification is a process driven by the demand for people to inhabit a space, area or city. On the urban scale the increased activity be it by more inhabitants, money or movement can all indicators of densification. For the most part this thesis will look at densification as a means to provide more dwellings and residential area (m2), since on the urban scale densification can be measured with different indicators, units and boundaries, whereas on the building scale, the act of densifying refers to mainly to the increased capacity to accommodate. Furthermore, densification, when done correctly, offers better living conditions and is one of the first steps and tool to improving the quality of life of the area. When more people start living in closer quarters it can lead to a greater number of services and amenities providing new business opportunities which tends strengthen the cycle of growth. From an urban planning perspective, this facilitates investment for public transport, schools and hospitals; essential components that all improve quality of life. This is not to say that densification always improves living conditions, bad urban planning can provide the essentials for social conflict and pollution arising from people living in closer quarters to one another.

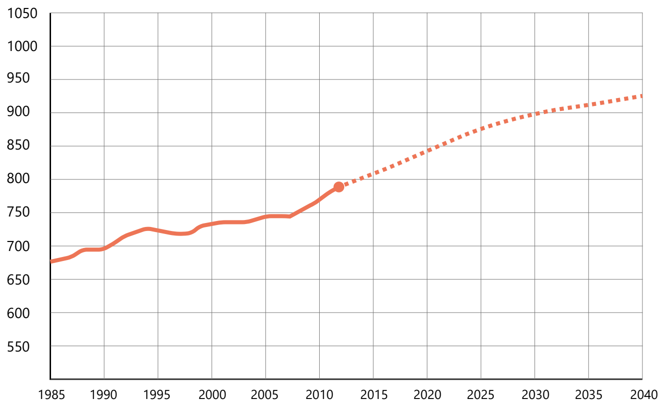


Figure 2.8: Population of Amsterdam and projections for 2040 (Amsterdam, 2016)

Amsterdam's Plans for Densification

The population of Amsterdam is growing at a heightening pace, Figure 2.8 shows the growth predictions for the city in the coming decades, rising by an approximate 10000 people a year. The continued population growth in Amsterdam has led to a greater need for housing which the municipality has realised and has set out some targets and principles to be completed by 2040 in a report titled 'Structuurvisie Amsterdam' (Structured vision for Amsterdam) published in 2011. Herein, an outlined 70,000 new dwellings is suggested by the end of 2040 using four spatial approaches for the city. These include, expansion of the city centre, improving the relationship between landscape and urban fabric, rediscovering the water front as potential urban expansion and lastly improving the international environment of the southern districts of Amsterdam (Amsterdam, 2011).

However, the rapid growth of Amsterdam following the realise of the aforementioned report in 2011 demanded an elaboration with amended targets. 'Koers 2025' was published in January of 2016; in it, plans for 50,000 new dwellings are made to be completed by 2025 (Amsterdam, 2016). Moreover, strategic areas around the city are highlighted, which demonstrate a potential for 20,000 to 25,000 new dwellings (see Figure 2.9). As can be noted, the research area for this thesis is one of those areas were the new dwelling space has been strategically assigned, making the analysis provided by this report more relevant to the current developments in the city.

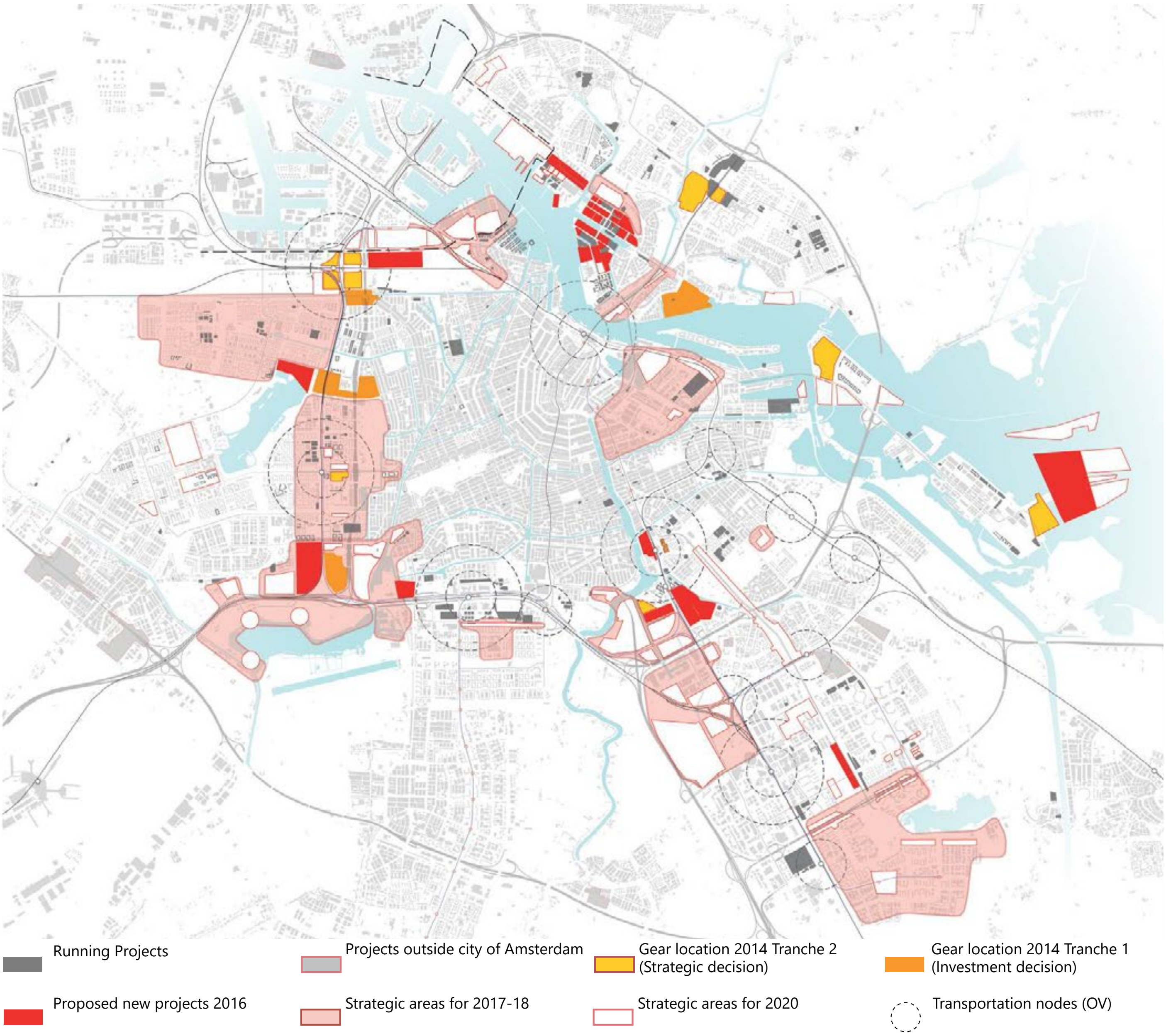


Figure 2.9: Map of Amsterdam showing strategic densification areas according to 'Koers 2025' (Amsterdam, 2016)

DENSIFICATION STRATEGIES

From other densification studies that have been carried out, five different strategies could be identified, two of which directly relate to residential building refurbishment. Table 2.10 provides a summary of each strategy but for the purposes of the thesis only two will be explored further. By investigating these strategies a densification potential analysis will be possible for both Top-up and Fill strategies.

Top-Up Potential

The Top-Up strategy is quite straightforward on a conceptual level, a flat roof provides at least the inquiry as to whether a new building volume can occupy that space, thus giving the unused roof space a certain spatial potential. In the potential analysis of this thesis the same criteria were taken from another study (Tillie et al, 2012) conducted in Rotterdam, which included applying one extra storey on flat-roofed buildings build after 1950's, as they were assumed to be constructed from concrete and/ or steel and would therefore be able to carry a layer of lightweight construction.

Fill Potential

The Fill strategy involves taking advantage of open urban blocks, in which spaces between buildings creates a potential for new dwellings space. The potential for new space depends on the individual configuration of urban blocks, in many cases an urban block typology can be identified as the same block configuration is repeated throughout an area. The method to access the potential of an area depends largely on identifying repeating open block typologies and with a quick design exercise, measure the extra space that can be added. The potential space should ideally not obstruct existing access routes, be it for pedestrians, cyclists or vehicles, and it should also not block existing windows from surrounding buildings.

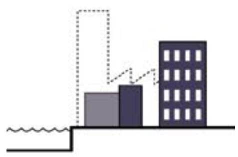
	STRATEGY	*DESCRIPTION*
Retrofit Measure	Top-Up 	Add new dwellings on existing roofs.
Retrofit Measure	Fill 	Construct new dwellings in the space between housing blocks. This strategy involves implementation on a small scale - block by block basis. Solving access to daylight and privacy issues demands tailor-made solutions.
	Fill 	Construct new dwellings in the open spaces of the city
	Reuse 	Convert unused offices or commercial spaces into dwellings.
	Restructure 	Re-structure abundant industrial and office area into mixed neighbourhoods

Table 2.10: Densification strategy table (Tillie et al, 2012)

Case Study Research

This part of the literature review also covers case study research conducted for both these densification strategies, in order to explore more specific consideration to involved with each strategy. These include the measures that were used to solve different design considerations. The design considerations include:

- Accessibility
- Architectural quality
- Energy performance
- Construction
- Structure
- Building services
- Fire safety

Case study #1 Melis stokelaan, The Hague

This Top-Up example was part of a major renovation project for this complex of portiekflats carried out in The Hague Zuidwest in 1999. A total of 273 dwelling were refurbished and 36 new dwellings were built on the existing structure of 6 different portiek-blocks. The project's ambition was to prolong the life of the characteristic apartment dwelling, which was deemed to have a desirable floor plan, by upgrading the access of the building and providing new unique dwellings (Crone, 2001).

With this in mind, this case-study provides a good insight into the following design considerations:

Architectural Quality

In terms of the existing dwellings, they not only benefited from an access upgrade, as the renovation accommodated the building with an elevator, but external space with the addition of new balconies which use the projected new entrance as primary support structure.

Accessibility

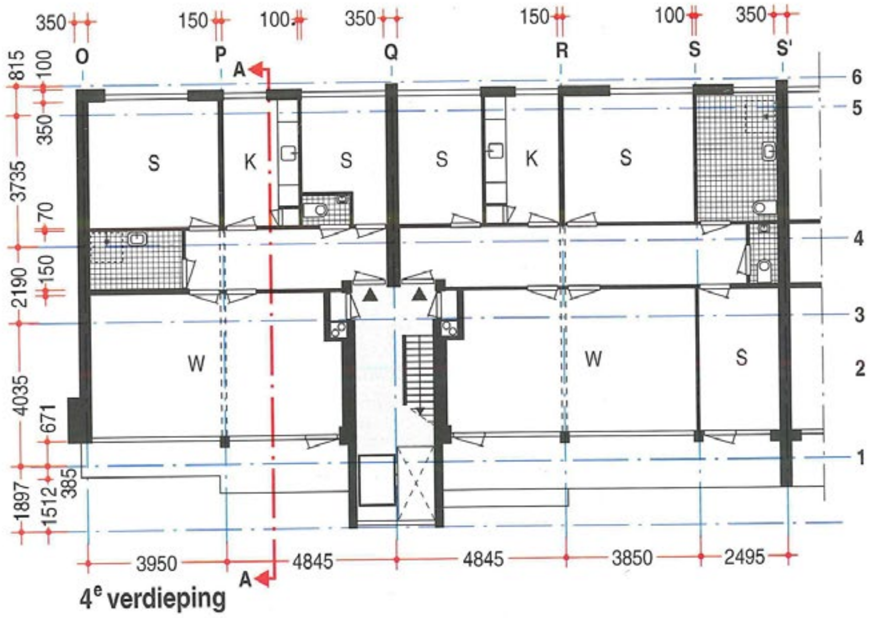
The renovation of a 1950's portiekflat requires a revision of the vertical circulation of the building, as most post-war apartments lack an elevator. In this case, a new straight-staircase replaced the typical half-landing staircase and a custom-sized elevator was installed on the external front of the building, meaning the entrance and stairwell had to be extended outwards by roughly 2 meters due to the spatial constraints, see Figure 2.11 where the plans highlight this point.

Structure

The foundations were deemed to have a enough bearing capacity leftover to allow for an extra storey to be constructed using primarily prefabricated aerated concrete elements. The new dwelling transfer its load through the prefabricated floors, which rest on rests on steel channels spanning along several concrete footings that have been connected to the existing load-bearing walls.

ARCHITECT:	Peter Jansen Schoorhoven
RETROFIT YEAR:	1999 - 2001
ADDED CAPACITY:	36 units

Figure 2.10: Top image: Street view of Melis Stokelaan. Bottom image: satellite image of all top-up blocks on Melis Stokelaan



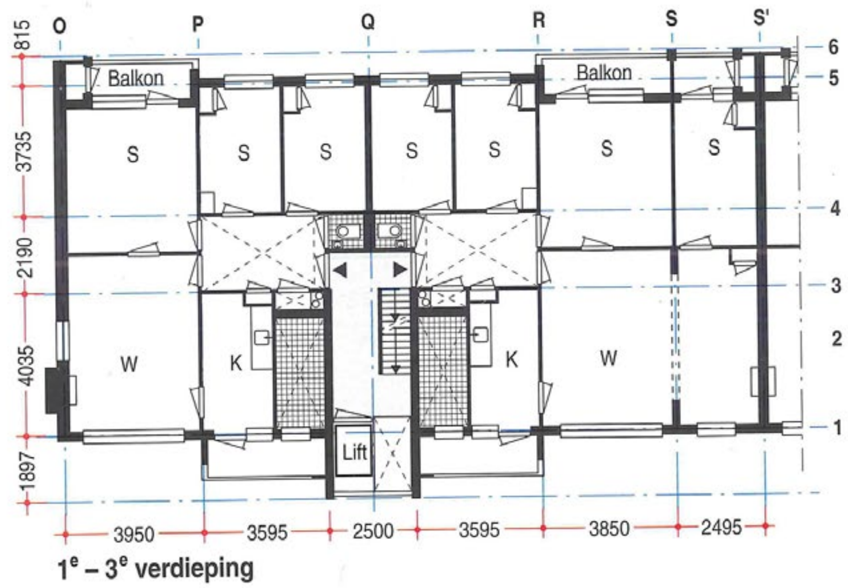


Figure 2.11: Floor plans of Melis Stokelaan

Case study #2 Rautistrasse, Zurich

A recently completed retrofit project of a historical 1940s office building now contains new loft-like maisonette apartments. The life of the existing building went through a couple of extensions, one in 1952, where 2 storeys were added with another more recessed storey being added in 1960. To realize the project it was necessary to remove the last 2 storeys and reinforce the existing structure (Fuchs, 2017).

Architectural Quality

The top-up includes 3 storeys and a roof terrace, making full use of the available space by stacking and interlocking the dwelling units vertically and horizontally, enabling access to all units via on central corridor on the 4th floor. In doing so, the dwellings benefit from 2 to 3 storeys and face both frontages of the building providing a town-house feel with a floor area ranging between 90 and 135m^2.

Structure

The underlying structure after the top two storey were removed consisted of facade piers and a central down-stand beam which distributed the load to a row of central columns along the middle of the building. For the Top-up a new load-distribution grid had to be introduced to make sure the new construction loaded the existing structure evenly. This structure consisted of two types of steel beams, one running the length of the facade with a depth of 300mm (HEB) and the other spanning the other beam and the central down-stand beam (Fuchs, 2017).

The down-stand beam had to be structurally retrofitted to cope with the new loads, which was achieved by topping it up with 160mm of reinforce concrete and using shear connectors and carbon-fibre-reinforced plastic (CRP). CRP was mainly applied longitudinally on the underside of the beam to improve its tensile strength.

Top-Up Construction

The construction is made up of lightweight timber platform frame system, using cross laminated timber (CLT) and timber box elements which could be used for the

ARCHITECT:	Annette Spillmann and Harald Echsle
RETROFIT YEAR:	2012-2015
ADDED CAPACITY:	16 maisonette units

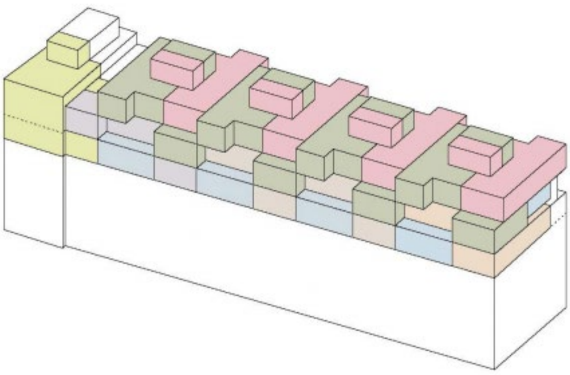


Figure 2.12: Top image: street view of Rauitistrasse top-up case-study. Middle image: satellite image of the block. Bottom image: isometric diagram of dwelling volumes and arrangement

floors and walls. The CLT panels were used as cross-walls to optimally direct the new loads to the existing columns. By building using this prefabricated panels system it was possible to install all wood element in a month, connecting the wooden elements by welded slitted sheets and self-drilling dowels (Fuchs, 2017.

Building Services

During the renovation phase the lower office levels were occupied and meant that the building services had to be separate from the existing pipes and ducts. Moreover, the existing heating system uses radiators, whereas the Top-up dwellings uses a low-temperature floor heating system (Fuchs, 2017.

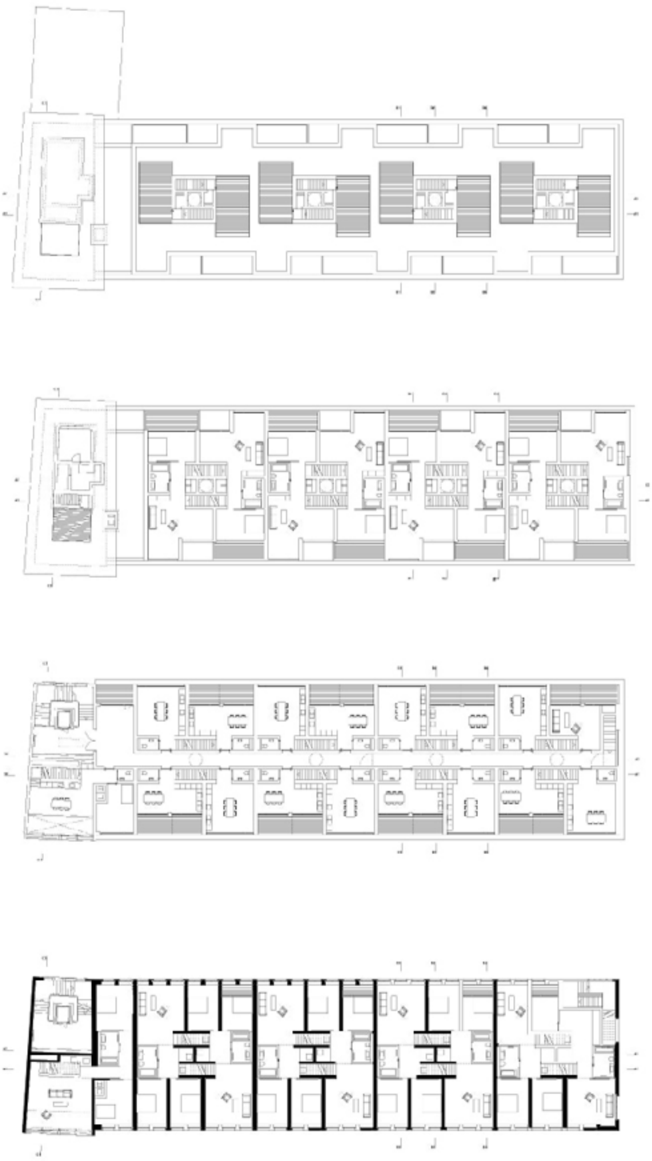


Figure 2.13: Floor plans of Rautistrasse

Fire Safety

In regards to fire safety the 2014 Swiss fire safety guidelines required that wood construction be dimensioned for a maximum of 30 minutes of charring together with a non-combustible cladding. Therefore all exposed wood surfaces from the CLT panel had to be covered in gypsum board, an aesthetic opportunity lost, which the regulation have rectified in the new fire safety guidelines that allow exposed wood with a pre-dimensioned charring allowance. Moreover, each maisonette constitutes a fire compartment (Fuchs, 2017.

Case study #3 v, Groningen - Lighthouses

Developed in response to the lack of residential space in the dense city-centre of Groningen and opportunity provided by flat roofs, these compact new dwellings provide a secondary level of dwelling in the historical city centre. The renovation by architects DAAD, provides four new dwellings that sit on top a new structure that penetrates the existing building.

Architectural Quality

The new top-up provide compact dwellings that provide a total of 41m2 of living area over 2 levels. With a completely new underlying structure they hover over the existing roof, which was remodelled into a roof terrace that serves as the main entrance level and communal space for the four dwellings.

Accessibility

The access is provided through a remodelled core to the rear of the retail space on the ground floor, incorporating a staircase (no elevator) and bicycle storage space. On the first storey there is the entrance to the lower level roof terrace with the access to the first dwelling, further up one level you find the same with access to the rest of the dwellings.

Structure

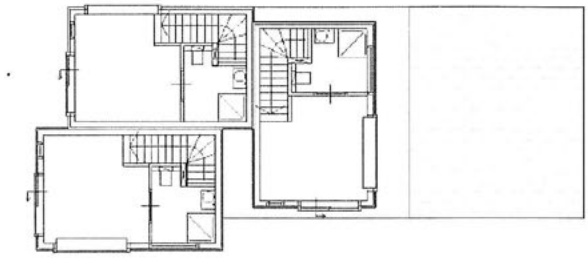
The structure of the new accommodation comprises of a new steel construction that pierces the building below and transfers the loads to new foundations. This was done because the old construction didn't have the bearing capacity for additional load. A drastic measure, especially considering that the new structure runs along the internal side of the existing building envelope but necessary given the lack of space available (de Vries & Teeuw, 2007).

Top-Up Construction

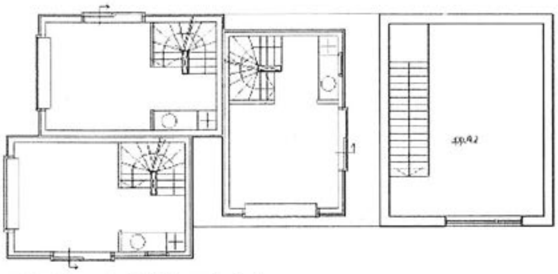
The construction was made possible by completely prefabricated the dwelling element modules made from a wooden construction to minimize the load-case (de Vries & Teeuw, 2007).

ARCHITECT:	DAAD Architects
RETROFIT YEAR:	2005
ADDED CAPACITY:	4 dwelling units

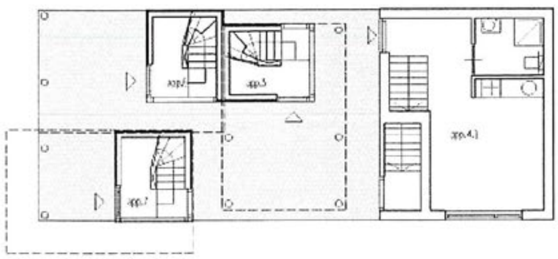
Figure 2.14: Top image: street view of Lighthouses. Bottom image: satellite image of top-up



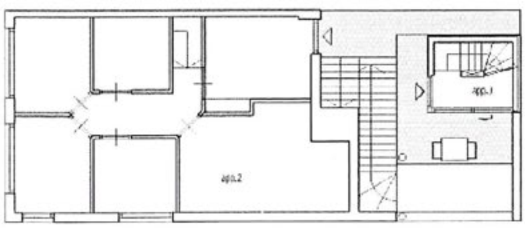
Laag 3 - 2e maaiveld (4e verdieping)



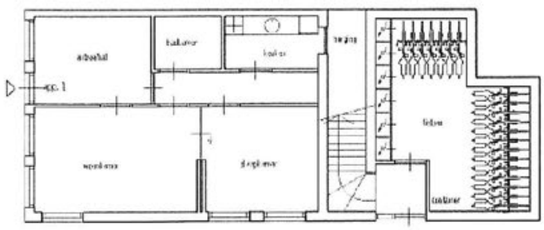
Laag 2 - 2e maaiveld (3e verdieping)



Laag 1 - 2e maaiveld (2e verdieping)



1e verdieping



Begane grond

Figure 2.15: Floor plans of Lighthouses

Case study #4 kamerstraat, Rotterdam

Built in a suburban area of Rotterdam, this neighbour is characterised by the various terrace and gallery-flat blocks that sit in a very green and open space. The various gallery-flats of the zone, which range from four to six storeys, all provide three to four bedroom flats, causing a monotone supply of dwelling typology in a time when modern demographics seek different types of accommodation and diversity above all is valued. Kolpa Architects concluded that the top-up solution was ideal for this case, as it allowed for a very quick supply alternative dwelling types, thereby diversifying the neighbourhood, without using up scarce land resources, preserving the characteristic surrounding greenery and allowing existing residents to stay during construction (ter Borch, 2007).

Architectural Quality

The new accommodation provided by the top-up comprises of various different sized two-storey maisonettes. Accessed via a common gallery, the first level comprises the bedroom area while the second level includes the living spaces, with kitchen, living and dining room all in one common space.

Accessibility

As the gallery block had already received an upgrade in the nineties, one of its circulation cores on either end had an elevator incorporated. For the top-up dwellings it was thus only necessary to extend the two cores, including the one elevator, which meant that the intervention was minimized. This also meant the top-up dwelling had to keep the gallery access style of the existing block, which does use a lot of space for circulation purposes but at an overall minimal cost when adjusting with other factors.

Structure

The structural engineer of the project was sure that the foundations would be able to support the new 'light' load-case but could not verify his claim with the archived existing drawings. Therefore, as a precaution new piles were hammered into the front and back of the long sides of the block at the ends and underneath of the concrete

ARCHITECT: Kopla Architects

RETROFIT YEAR:

ADDED CAPACITY:

Figure 2.16: Top image: street view of Kamerstraat top-up case-study. Middle image: satellite image of the block. Bottom image: Floor plans of Top-up

beams to act as a safety resort. The dwellings were then constructed directly on top of the existing loadbearing walls using so called steel feet which are bolted on the top of the existing wall and carry a transverse steel beam. The method of installation means that the existing roof can be preserved and more importantly that work on the new dwelling does not disrupt the residents of the building (ter Borch, 2007).

Top-Up Construction

The construction was facilitated with the use of steel allowing for a speedy assemble of lightweight floor, wall and roof elements through the benefits of prefabricating those elements. The construction mainly follows the original grid of the gallery block at intervals of 7.5m, however, to further reduce the floor depth by 5cm an intermediary support was placed at 4.75m, this can be noticed in the floor plans shown in Figure 2.16. By dividing the space in this fashion it makes it more appropriate to locate the bedrooms in the first level, in which a division of space is necessary given the structure, and the communal spaces in the top level to take advantage of the open column-free floor plan.

Building Services

The new services such as plumbing, drains and ducts were located in the intermediary space between the new construction and the exiting roof. A total crawl space of 400mm was allocated for this service region, providing flexibility to the floor plan to accommodate the services. Pipes and ducts are carried to the edge of the building to a central point on the side of the gallery access, where they ascend from there. Again this intervention allowed minimal disruption to the existing dwellings, as existing drainage was left untouched, and provided them with a new extraction system (ter Borch, 2007).

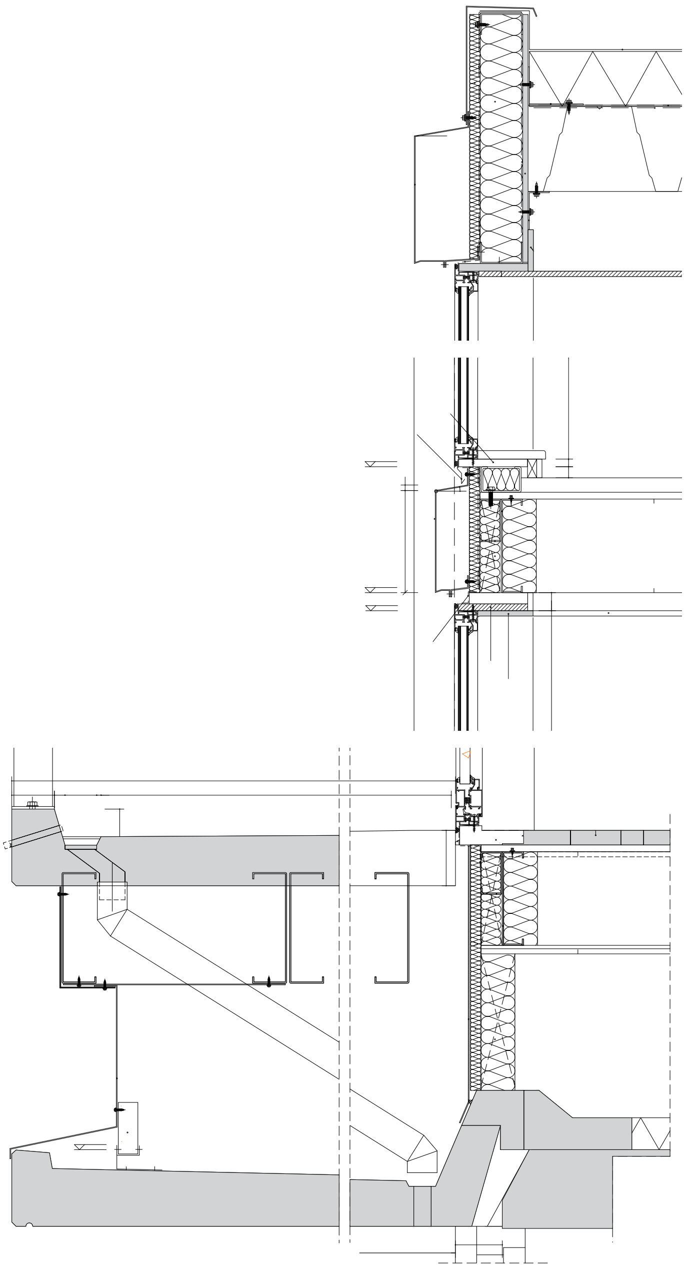


Figure 2.17 Detailed section thorugh front facade of top-up (ter Borch, 2007)

Top-Up case-study research Evaluation

The five different case-studies show how a top-up was successfully completely for different types of buildings as well as different approaches employed given the design aspect in question. The two main design aspects discussed that will in reality determine the viability of the top-up were structural and access. The other aspects, in this respect, come secondary and follow-up on the first two.

The vertical access was resolved in different ways depending on the type of building and the case-studies covered simple extending the vertical core, remodelling it or constructing a completely new core to access the new construction. One of the main consideration is accommodating elevator access to the new top-up; in both Rautistrasse and Kamerstraat were an elevator was already present it was possible to simple extend the shaft, a relatively minimal intervention. Melis Stokelaan, on the other hand, a four-storey 1950s building without the presence of an elevator, required its vertical core to be completely remodelled to accommodate new circulation standards. The Lighthouses did not need an elevator as the Top-up was done on a two-storey building. Nevertheless, due to restriction to access the roof space of the building a new vertical core accommodating a stairway needed to be constructed. Resolving the access inevitable comes down to three main approaches, extend, remodelled or construct a vertical core to access the top-up.

The other crucial aspect to consider for Top-Up is structure, specifically how the existing building can manage the new load case. The assumption from the study focussing on densification in Rotterdam (Tillie, et al., 2012), is that buildings constructed after 1950's with a concrete frame have the sufficient structural capacity for an additional floor; an assumption that holds true in the examined case studies. For the most part, the case-studies use the existing structural capacity for the Top-up, the only exception being the Lighthouses which use a completely new structure that penetrates the existing building and brings the loads down to new foundations. In essence, three main approaches can be identified, the first being not structural intervention required as existing conditions provide sufficient support for Top-up, as in Melis Stokelaan; secondly, the reinforcement of structural members to accommodate new load case, as in Rautistrasse and partially in Kamerstraat; and lastly, the complete structural accommodation by an autonomous new structure, which as exemplified by the Lighthouse, allows for a degree in design flexibility and dwelling accommodation not available with the other approaches.

The other design aspects, construction and building services, delve into more technicalities, which no doubt are interdependent on the approaches for access and structure. The fact that a new load-case, which the original building was not design for, means that construction measures have to provide lightweight dwellings that minimize the loads. This is evident in all case-studies that used lightweight materials such as wood, steel and aerated concrete. The advantages of using wood or steel allows for large prefabrication elements which lead to quick assemblies, a desirable trait as time and money can be minimized. In terms of building services, in all cases, except the Lighthouses, the new services run in between the top-up and the existing building and run into a new service duct, which meant that spatial planning of the Top-up dwellings required efficient location of pipes and ducts in order to minimize the distance between the new Top-up floor and the exiting roof. These measures explored and summarized in Table 2.11, will help inform the design stage of the final retrofit.

	MELIS STOKELAAN, THE HAGUE	RAUTISTRASSE, ZURICH	RABENHAUPTSTRAAT, GRONIGEN	KAMERSTRAAT, ROTTERDAM
				
ACCESSIBILITY	• External added • Half-landing staircase replaced with straight staircase	• Exisiting vertical acesss used	• Complete externalization of vertical circulation	• Exisitng vertical circulation extended and one external elevator incorperated
STRUCTURE	• New loads carried by existing structure	• Reinforced structural members to increase structural capacity and distribute new loads	• Top-up stands on its own new columns that have been integrated into the existing building	• New-loads carried by existing structure
CONSTRUCTION	• Prefabricated aerated concrete elements	• Prefabricated timber platform construction • CLT panels used as crosswalls	• Completely prefabricated units stacked on top of each other	• Prefabricated steel elements
BUILDING SERVICES	• Services placed between first floor of top-up and existing roof. • Runs into existing shafts	• Top-up dwelling services seperate from existing building services. • Plumbing and ducts placed in between top-up adn existing elements.		• Services run between first and top-up floor • Plumbing runs into existing drains

Table 2.11: Top-up case-study summary

LITERATURE STUDY CONCLUSION

Having covered strategies both densification and energy for building retrofits, it is evident that there is a certain overlap, which the next sections of the thesis will look to exploit on a building stock of the research area. However, this section concludes the main points derived from the literature study of the two retrofit aim that will help provide starting points for the next sections of the thesis.

Energy Retrofitting

Energy retrofits will play an important role for the future development of the existing building stock but we are yet to see an accelerated movement of retrofits throughout Europe. Given the circumstances, deep retrofits that provide between 60% and 90% are needed if C02 targets reductions are too be met by 2050, in other words, comprehensive retrofit strategies that involve and integrate solutions for all building elements of the envelope will be required.

Within the Netherlands, the assessment of building energy follows the EPC norm and the country has, under the EU guidelines and regulations, adopted an incremental increase in the regulations that build towards NZEB standard by 2020 for new builds. Even though there are no specific retrofit standards as of yet that follow the same NZEB concept as in new builds, deep retrofits, that is a renovation that involves more than 25% of the building envelope, most still comply with the technical requirements for the envelope as outlined for scoring an EPC of 0.4. Both NZEB and EPC 0.4 envelope requirements are listed in Table 2.12 and will serve as starting points for the retrofit design. They demonstrate that one of the main priorities in a retrofit design is to improve the thermal resistance of the envelope components.

Retrofit strategies in terms of the building envelope and their subsequent measures were covered in a categorized manner to be able to compare and evaluate them in terms of the advantages they offer regarding their effectiveness to improve the energy performance. These strategies were further explored using the case studies of 4 different projects. It showed that the 'wrap' and the 'replace' strategy provided the ability to achieve the most rigorous energy improvements. As most constructions possess a cavity wall construction, by intervening on the external leaf of the envelope it is possible integrate different measures for different building elements better, thereby eliminating thermal bridges at the junctions and with an enhanced ability to control air-tightness.

Densification

The need to densify within the city of Amsterdam will also play an important role in which the existing building and urban environment will play a deciding factor in how it occurs. Regions of Amsterdam Nieuw-west and specifically the research area have already been identified as strategic areas for densification by the municipality. The literature study identified a total of 5 different densification strategies, of which two strategies directly involve the refurbishment and involvement of an existing building; these included Top-up and Fill. Their assumptions and requirements behind the two strategy were also explored with reference to other densification studies so that they could be similarly used in the research area for the analysis of the suitable building typology.

STANDARD	*NEW BUILDINGS 2015-*	*NZEB*
EPC	0.4 minimum	0
Primary energy (kWh/m^2 annual)		60 to 15
U-value roof (W/m^{2}K)	≤ 0.17	≤ 0.17
U-value facade (W/m^{2}K)	≤ 0.22	≤ 0.22
U-value floor (W/m^{2}K)	≤ 0.29	≤ 0.29
U-value glazing (W/m^{2}K)	1.65 as average	≤0.8 (50% g-value)

Table 2.12: Perscriptive thermal resistance values for EPC standards according to Dutch regulations

The Top-up case studies provided insights into what design aspects underline the success of a Top-up, specifically Accessibility and Structure, and what approaches were used to resolve the issues regarding this for each individual case. The essential approaches for Accessibility include either extending the vertical core if an elevator is already present in the building, remodelling the vertical core to accommodate a new elevator if the Top-up, in other words the new dwelling, is above 2 storeys; and lastly incorporating a new vertical core to access the Top-up. For the structural aspect, together with a lightweight construction, considerations into whether the existing structural members do or don't require strengthening needs to be understood in order to respond with an appropriate structural approach. These approach can range from no structural intervention to strengthening structural members or foundations or bypassing the existing structure with a completely new structure to bear the new load-case.

Concerning the case studies for the Fill strategy, these were omitted from the thesis, as the results from analysis of these strategies on the research area showed this strategy to be negligible compared to the Top-up strategy, this will be elaborated on in Chapter 4.

3. CONTEXT ANALYSIS

RESIDENTIAL TYPOLOGIES

This chapter provides a general analysis of the area, shown in figure 3.1, which includes 3 main districts within Nieuw-West, which total 11 different neighbourhoods. The aim of this part was to gain a clear understanding of the existing residential building stock energy demand, by categorising the stock via their typology and age group. The classification for each building typology is shown in Table 3.1. Along with this classification, the buildings footprint, number of dwellings, construction year, type of roof and storey number was recorded to assist in the subsequent analysis of the area.

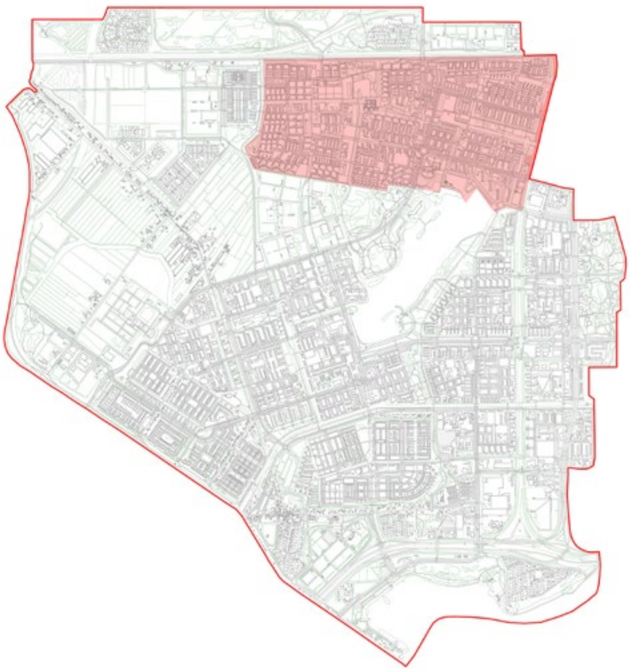
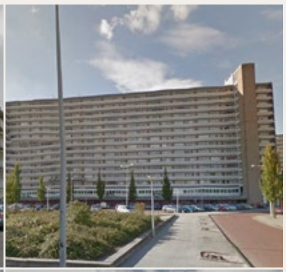
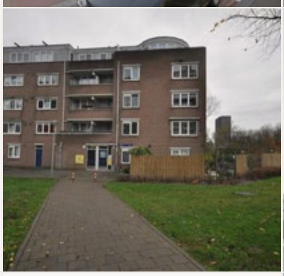
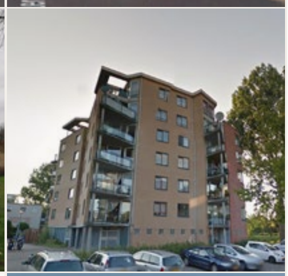
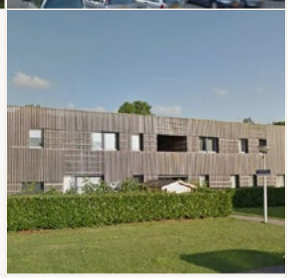


Figure 3.1: research area in Amsterdam Nieuw West

TYPOLOGY	*DEFINITION*
Apartment block – Portiekflat	Apartments with internal access through an internal Staircase
Apartment block - Gallery-flat	Apartments with external or Internal staircase giving access to an external gallery to access dwellings
Rowhouse	A group of single family dwellings that share between 2 and 1 wall.
Multifamily house	A type of housing where multiple dwellings are contained within one building.
Semi-detached house	A single family dwelling built in pairs, which share a common wall.
Detached house	A free standing single family dwelling

Table 3.1: Building typology classifcation according to year group and dwelling type. Images taken from google maps

1950-1959	1960-1969	1970-1979	1980-1989	1990-PRESENT
				
				
				
				
				
				

MAPPING

The research area contains around 860 urban blocks comprising 16743 dwelling units all of which were categorized into the already described typologies within a total of 11 different districts as shown in Figure 3.2. To find out what the other important building characteristics were, several maps were used from different sources, these were critical for recording the energy demand regarding gas and electrical for a given year, the year of construction and stakeholders. Figures 3.3 to 3.8, show the maps that were used for this exercise. The collection of all the data related to each building typology is presented in Appendix A, of which, in the following pages, the results of their important properties and characteristics are presented.

Year of Construction

The year of construction was a defining characteristic for the building typology as each typology was subsequently categorized by its year group as illustrated in Table 3.1 on the previous page. Figure 3.6 was used to decipher this information. Evidently, the region in question only contains buildings constructed after WW2, with most buildings corresponding to the in the period between 1950 and 1970.

Energy

The energy maps visualize both electrical and gas consumption data from the year 2012 for each urban block. Using this data, the equivalent C02 emissions per m3 could be calculated for the building stock. Furthermore, Figure 3.5, showing the EPC labels of the different blocks further informs the typical energy performance found in the research area, with most building performing below a label C.

Stakeholders

Stakeholders from the building stock were identified with two relevant maps; the first one shows general ownership classification (Figure 3.7), divided up between social rental, private rental, and owner-occupied; the second map showing the different ownership of buildings by social housing cooperation (Figure 3.8).

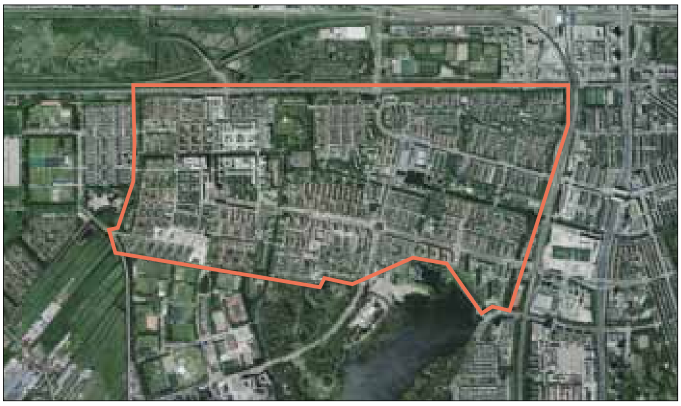


Figure 3.2: Research area in Amsterdam Nieuw-West

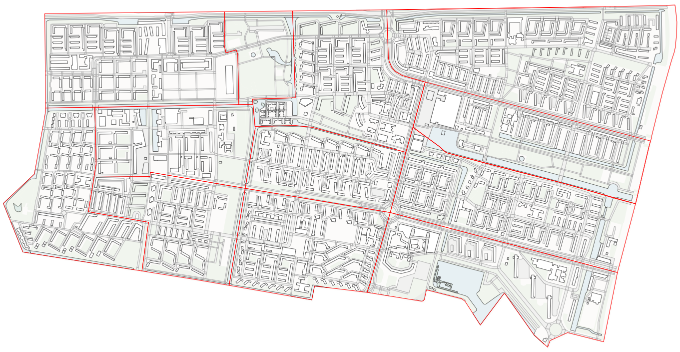


Figure 3.2: Map showing the division of different districts within the research area.

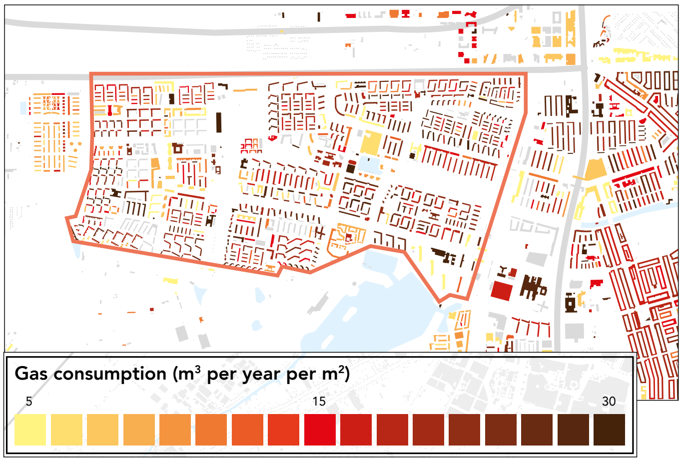


Figure 3.3: Map showing gas consumption of building blocks for research area (den Boogert, et al., 2014)

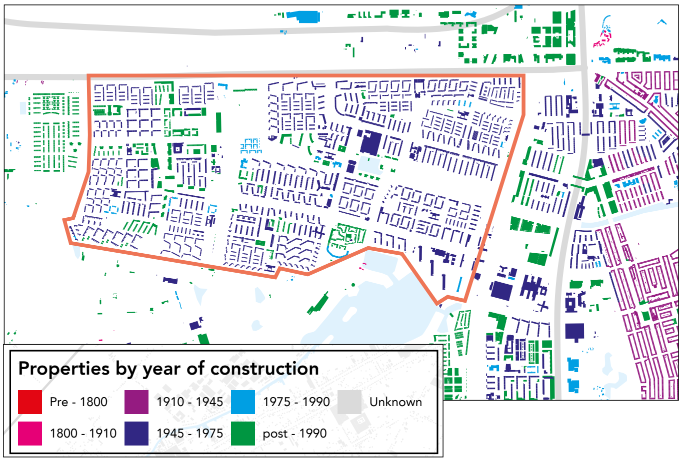


Figure 3.6: Map showing year of construction of building blocks for research area (den Boogert, et al., 2014)

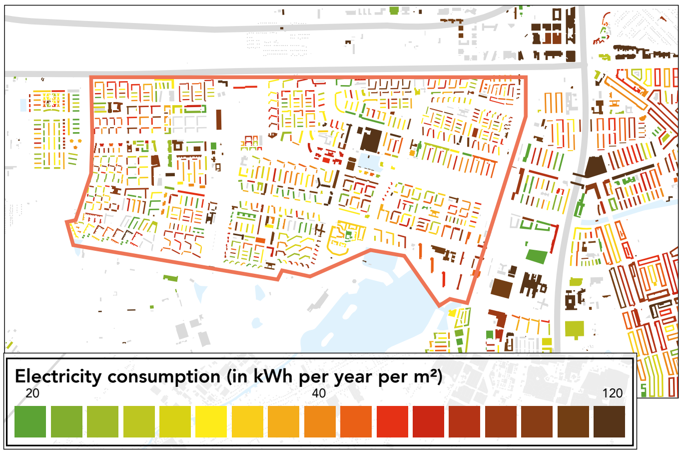


Figure 3.4: Map showing electricity consumption of building blocks for research area (den Boogert, et al., 2014)

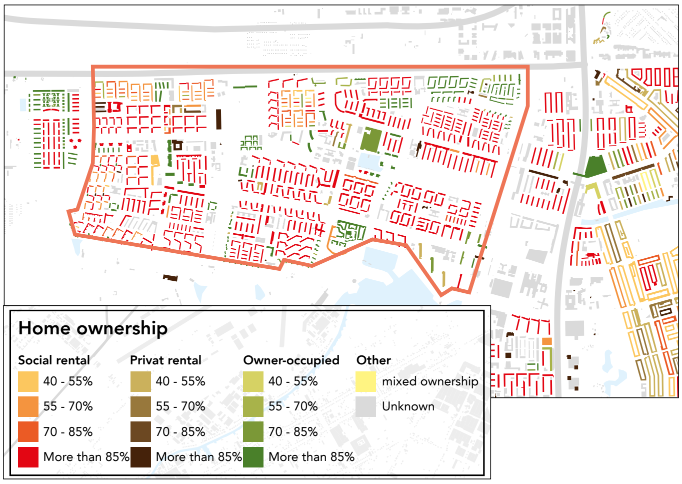


Figure 3.7: Map showing the stakeholder type (home ownership) of building blocks for research area (den Boogert, et al., 2014)

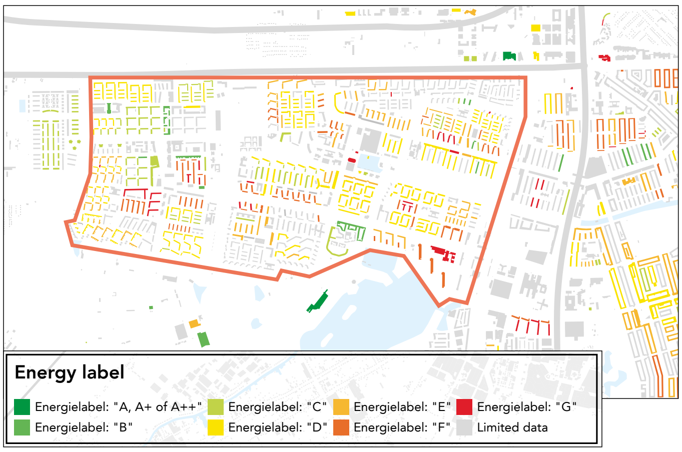


Figure 3.5: Map showing energ label (EPC) of building blocks for research area (den Boogert, et al., 2014)

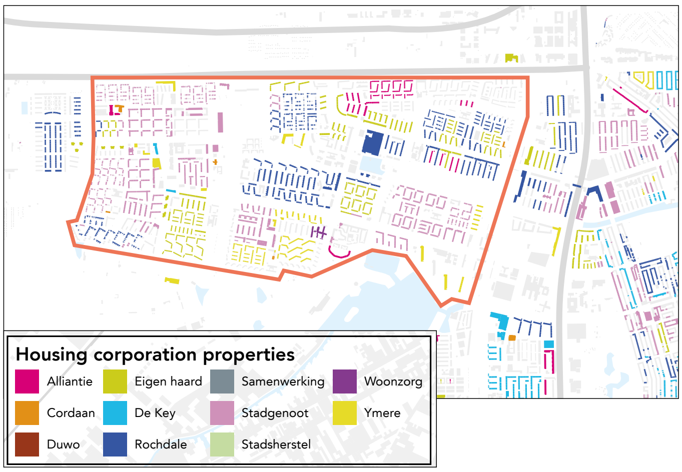


Figure 3.8: Map showing the ownership of social housing corperations for research area (den Boogert, et al., 2014)

RESULTS

Building Typologies

The following map illustrates the building typology according to the definitions presented in Table 3.1, shown in Figure 3.11. Along with map the results for the quantity of dwellings per typology is shown in the Figure 3.9; evidently the area is comprised mainly of residential buildings from the 1950s, with the majority of dwellings corresponding to portiekflats. The second majority is made up of rowhouses from the same period. However, from the map, it would seem that rowhouses occupy a larger spread than portiekflats. In fact, when comparing dwelling area their totals are much closer than when comparing the number of dwellings, with portiekflats at roughly 400000m2 and rowhouses at 360000 m2 from the 1950's, as shown in Figure 3.10. This is to say, that both these typologies from the post-war period account for the largest amount building space in these 11 different neighbourhoods.

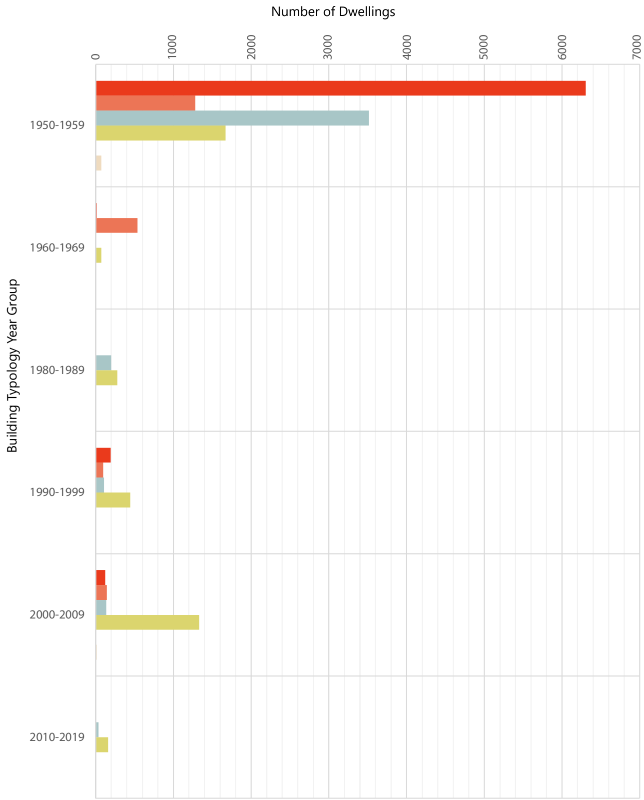


Figure 3.9: Chart with number of dwelling per building typology

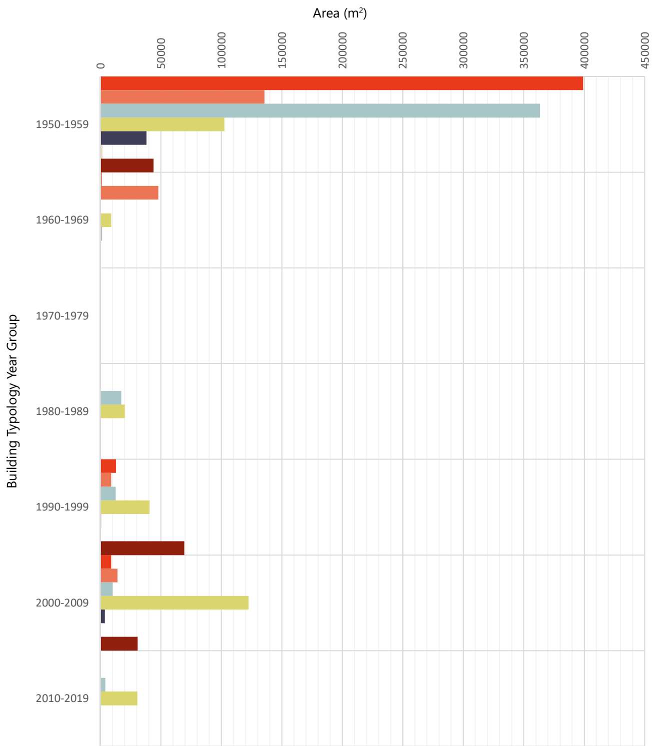


Figure 3.10: Chart with area of dwelling per building typology

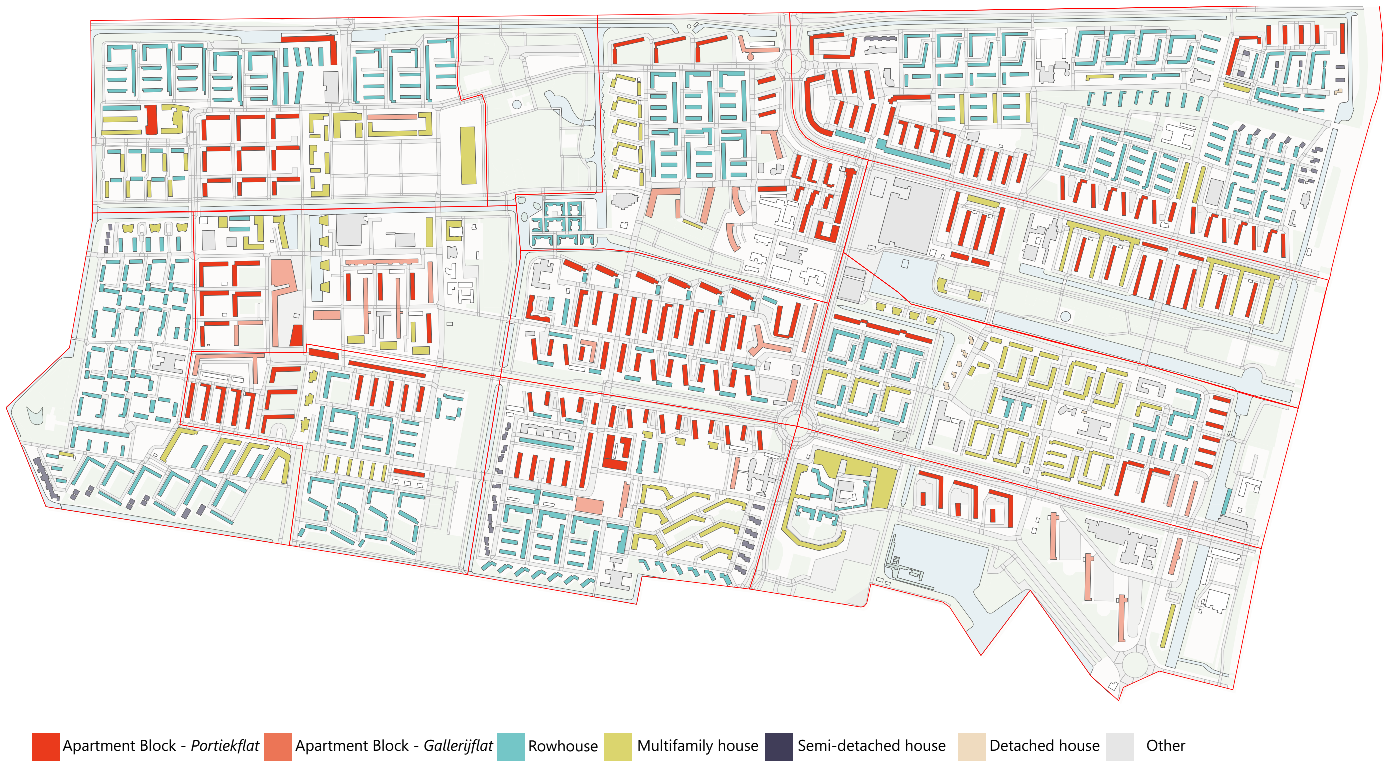


Figure 3.11: Map of reasearch area showing building typologies

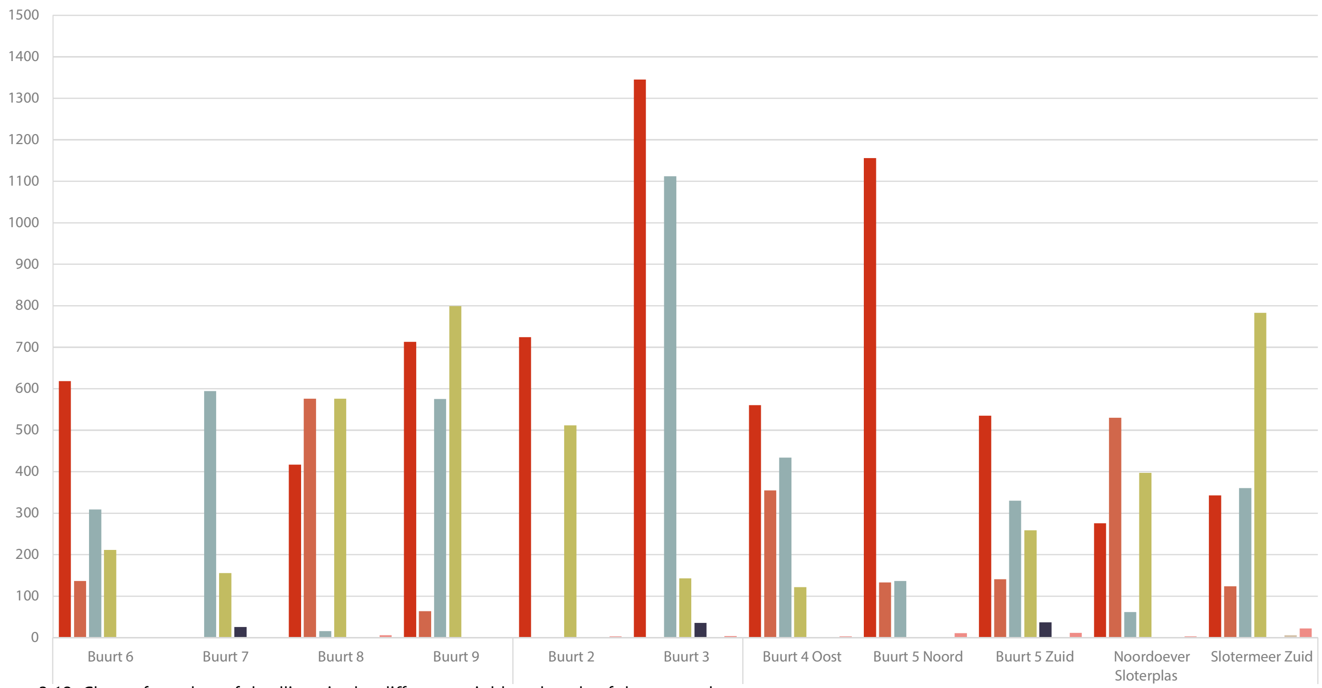


Figure 3.12: Chart of number of dwellings in the different neighbourhoods of the research area

Stakeholders

The stakeholders were also analysed according to the building typology, with the results presented in Figure 3.13 and 3.14. The first graph shows the general type of stakeholder found in the area, these include owner occupied meaning the person who owns the dwelling is the one living in it; private rental, also known as free sector, these are properties that are normally not controlled by rent caps and are owned by private interests; lastly social rental, dwellings owned and rented out by social housing corporations who have a duty to provide affordable housing to the most financially vulnerable demographics. The mapping showed that the majority of dwellings from all building typologies belong in the social rental sector, a staggering estimate of 75% of all dwellings. With such a significant proportion of social housing units in the area, a secondary map was used to highlight the ownership between different housing corporations, which is shown in Figure 3.14.

Type of Roof

The type of roof was analysed through the use of google maps and categorized under a variety of different roof types, the results are shown in Figure 3.15, where a total 8 different roof types were identified. The majority of buildings employ an open gable and flat roof in this respective order. These results are important for the densification analysis as flat roofs present a potential for Top-up, see the previous chapter on densification.

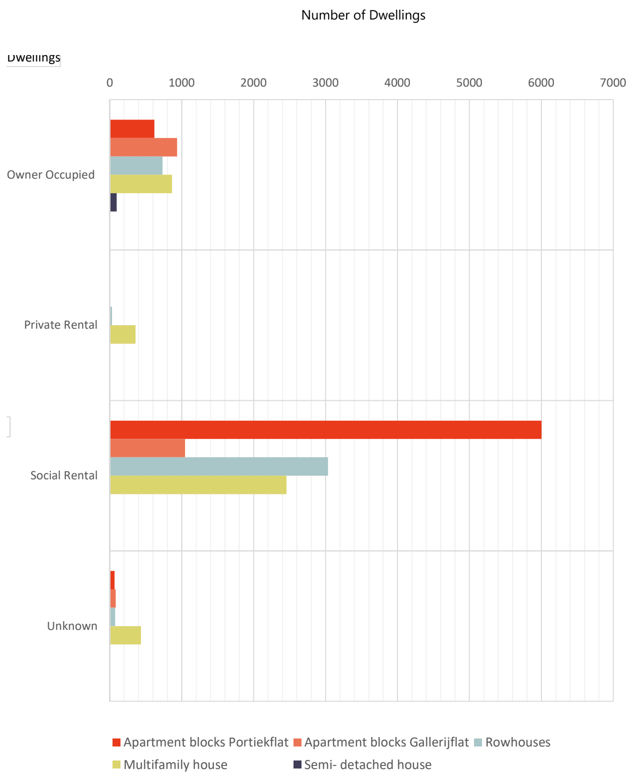


Figure 3.13: Ownership chart of building blocks in research area

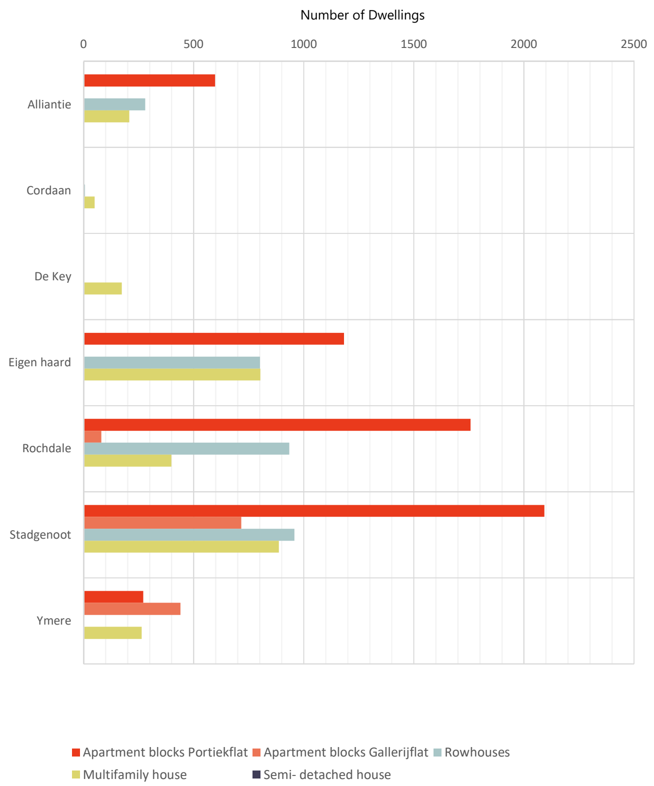


Figure 3.14: Ownership chart of social housing corporations

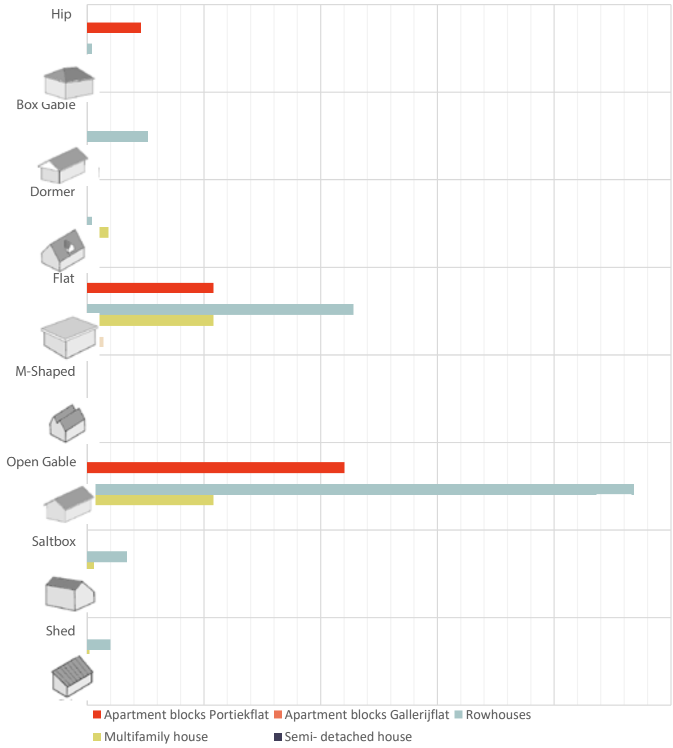


Figure 3.15: Roof types for the building blocks in research area

Energy Demand

The main purpose of this section was providing a clearer picture of the energy demand of each building typology, specifically for space heating demand as that is the primary target of an energy retrofit. The method included recording the gas and electricity demand of each urban block of the area (http://maps.amsterdam.nl/energie_gaselektra/?LANG=en) together with the usable floor space of the building, it provided the necessary data to determine an estimation of the energy demand per unit of area. Furthermore, between the electricity and gas demand, gas was used as an indicator of the space heating demand of the building and the subsequent conversion to C02 emissions. In some cases, mainly building built in the last 10 years, there was no gas recording available so the electricity was taken as an indication of their space heating demand as it still remains the largest portion of the energy profile of these buildings.

The findings for space heating demand per unit of area for each building typology is shown in Table 3.2, bear in mind that these are only an estimation based on 2012 consumption figures. They show a clear trend across all typologies that the newer the building the less energy it consumes for heating. The largest energy consumer of the typology in the area are the semi-detached houses with 225kWh/m2, whereas the lowest is gallery-flats with 106kWh/m2. As a building typology, this would make sense, as the larger more compact typologies, Gallery-flats, portiekflats and some multifamily houses, have a better form factor (the ratio between the thermal envelope area and their usable floor space). Given the large sample size for many of the typologies and their respective time periods, the findings can provide a good picture which is consistent with common sense, the older the building the larger the more energy it needs for heating.

With this data was then possible to determine the total

	1950-1959	1960-1969	1980-1989	1990-1999	2000-2009	2010-	**AVERAGE**
Portiekflat							
Heating (kWh/m^2 annual)	185	76		129	71		**182**
Quantity of blocks	179	1		4	3		**187**
Gallery-flat							
Heating (kWh/m^2 annual)	134	59	106	35			**106**
Quantity of blocks	19	5	2	4			**30**
Rowhouse							
Heating (kWh/m^2 annual)	200		155	130	61	26	**189**
Quantity of blocks	354		22	12	14	3	**405**
Multifamily house							
Heating (kWh/m^2 annual)	205	192	144	115	92	27	**158**
Quantity of blocks	71	3	2	13	32	6	**127**
Semi-detached house							
Heating (kWh/m^2 annual)	250	256		169	154		**225**
Quantity of blocks	36	1		4	10		**51**
Detached house							
Heating (kWh/m^2 annual)	205						**205**
Quantity of blocks	7						**7**

Table 3.2: Heating average per building typology and year group.

proportion of C02 emissions by building typology for the area, thereby enabling an understanding of what building typology causes the largest C02 emission for the area of Nieuw-West. These results are illustrated in Figure 3.15, with a total emission of 37760 tons of C02 accounted by all buildings and as expected the largest proportion is attributed to the post-war era buildings, with portiekflats contributing the most with 35% followed by rowhouses at 23%.

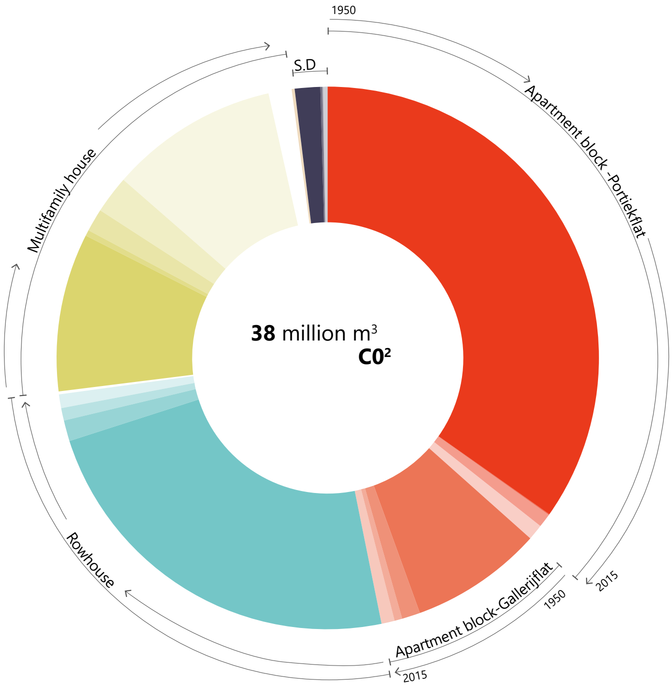


Figure 3.15: Pie chart of C0² emission per buidling typology

4. SUITABLE TYPOLOGY

This chapter aims to combine the results from the literature study and context analysis to form a viable approach that allows for the identification of the most suitable typology for energy retrofit and densification for the given area. The suitability, as aforementioned, of a typology, in this case, depends primarily on the energy-saving and densification potential. It is derived from a top-down approach in which the necessities, as well as the goals of a given urban area, are first taken into account, in this case retrofitting and densification, so that measures used to address those necessities are prioritized given the building typology.

With regards to energy retrofit, there are several European research projects and initiatives that deal with providing substantive information regarding the current state of the building stock and evaluating the energy-saving capacity. The crucial first step was recording the characteristics of the building stock to be able to categorize each building into a building typology; this step has been completed in the Context Analysis chapter. For this thesis, specifically Tabula been used to inform the analysis for the approach.

The densification potential of a typology, focusses specifically on the amount of area (m2) can be created using the strategies for a given building typology. To access the potential, the assumptions and methods were covered in the literature review and will be repeated in the densification potential analysis in the following pages.

TABULA

Tabula (2012) aimed at creating a harmonized structure for building typologies across European countries in order to create a set of national model residential buildings with their equivalent energy-related properties. It offers starting points for each European country into what type of buildings exist, how they can be retrofitted and it's resulting impact on energy (Episcope, 2016). The data relevant from this platform that is vital to this chapter's analysis is the following:

- The classification of residential building stock into building typology organized in size and age classes
- Data on building typologies via reference case. This includes visual appearance, construction characteristics, corresponding U-values.
- A set energy-saving measures for building components given two different quality levels (A minimum and advanced improvement)
- Standard reference calculation for the energy performance of each building typology.

For the Netherlands the building typologies are structured similarly to how they were in the Context Analysis, allowing the pairing of the Tabula results with the previous chapter results. Moreover, concerning energy-saving, the results show retrofit measures according to current practices and nZEB standard as stipulated by the 'Rerentiewonigen nieuwbouw 2013,' meaning an improvement to 0.6 EPC. This entails upgrading the thermal envelope to prescribed standards set by regulation.

THE APPROACH

The approach aims to outline how a specific building typology is most suitable for energy-saving and densification. In this sense, concerning energy-saving, it is the typology that demonstrates the greatest amount of energy saved when applying a standard set of retrofit measures, which provide the benchmark energy-reduction for each typology. Data from tabula was used to influence this analysis, summarized in Table 4.1. For densification, it means analysing which building typology after having applied the strategies, has the potential to create the most amount of dwelling space. These two objectives are the underlying requirements for the development of the retrofit design. Moreover, a retrofit or even the construction of a regular building is designed and built for a specific stakeholder, who's interests strongly influence the design brief. Therefore, it is crucial that the suitability approach also include the type of stakeholder so that the design of the retrofit can incorporate the interests of the group. As already highlighted, the majority ownership group in the research area are social housing corporations; thus, the thesis will focus specifically on the building typologies owned by this stakeholder.

In summary, the most suitable typology is the building typology with the greatest potential for energy-saving and densification corresponding to one type of stakeholder. This approach can create several groups of different building typologies owned by various stakeholders for which a retrofit design can be tailored for. However, this thesis will only focus on the building typology owned by the largest stakeholder type.

In the following pages the results for energy-saving and densification for all building typologies are illustrated followed by a discussion on how these results filter when focussing on social rental stakeholders.

	Heating Energy (kWh/m²/a)				
	Existing State	Partial Retrofit	Reduction Percentage	Advanced Retrofit	Reduction Percentage
Apartment Block Portiekflat					
1950-1959	139.6	59.5	57%	36.8	74%
1960-1969	120.3	61.5	49%	37.5	69%
1980-1989	90.8	56.9		35.5	57%
1990-1999	78.5	55.6		33.9	53%
2000-2009	57.8	54.2		29.6	49%
2010-	59.1	-		29.1	41%
Apartment Block Galleryflat					
1950-1959	122.1	61.2	50%	35.5	71%
1960-1969	120.3	61.5	49%	37.5	69%
1980-1989	90.5	57.1	37%	35.0	62%
1990-1999	67.3	53.8	20%	31.4	53%
2000-2009	57.8	54.2	6%	29.6	49%
2010-	59.1	-	-	29.1	41%
Rowhouses					
1950-1959	156.7	63.6	59%	40.1	74%
1960-1969	122.5	61.6	50%	37.1	69%
1980-1989	108.9	63.2	42%	40.5	63%
1990-1999	69.4	55.6	20%	33.5	52%
2000-2009	59.4	56.9	4%	31	48%
2010-	60.3	-	-	30.3	50%
Multifamily House					
1950-1959	127.8	60.0	53%	36.5	71%
1960-1969	104.2	55.7	47%	31.9	69%
1980-1989	91.7	55.9	39%	33.8	63%
1990-1999	67.0	54.0	19%	31.8	53%
2000-2009	56.5	55.0	3%	28.0	50%
2010-	58.2	-	-	27.6	53%
Semi-Detached House					
1950-1959	154.3	67.8	56%	44.1	71%
1960-1969	141.1	66.3	53%	42.9	70%
1980-1989	103.8	63.2	39%	39.9	62%
1990-1999	82.8	60.6	29%	38.1	54%
2000-2009	63.2	57.5	9%	33.6	47%
2010-	63.2	-	-	32.5	49%
Detached House					
1950-1959	166.1	71.1	57%	48.0	71%
1960-1969	156.5	70.6	55%	47.3	70%
1980-1989	103.8	63.2	39%	39.9	62%
1990-1999	82.8	60.6	29%	38.1	54%
2000-2009	68.5	63.2	8%	36.7	53%
2010-	68.8	-	-	35.7	48%

Table 4.1: Tabula results showing benchmark energy savings for each typology and year group (Episcope, 2017)

ENERGY-SAVING POTENTIAL & C02 REDUCTIONS

In the previous chapter the highest emitting typology was identified, with this alone there is enough to justify a concentrated retrofit approach for the portiekflat typology of the 1950's. However, this part will further elaborate on much can actually be reduced per typology in terms of energy savings and C02 reductions. Table 4.1 summaries the energy saving results from the Tabula database into the appropriate building typology categorizes, these figures are then applied on the average heating demand of each typology, these results shown in graph xx. It shows how the greater the energy demand the larger the savings can be with a general trend of older buildings pre 1970s having the greatest savings. These energy savings for the different urban blocks of pre 1970s buildings are visualised in the axonometric map shown in Figure 4.1.

The average heating demand per unit of area for each building typology was then translated into the actual C02 savings that can be achieved per building typology, these results are shown in Figure 4.2. From this graph it becomes clear that the benchmark energy-savings of 1950's Portiekflats and rowhouses can result in the largest reductions of CO2 emissions for the area, representing 25.5% and 16.6% respectively of the total possible emission reduction.

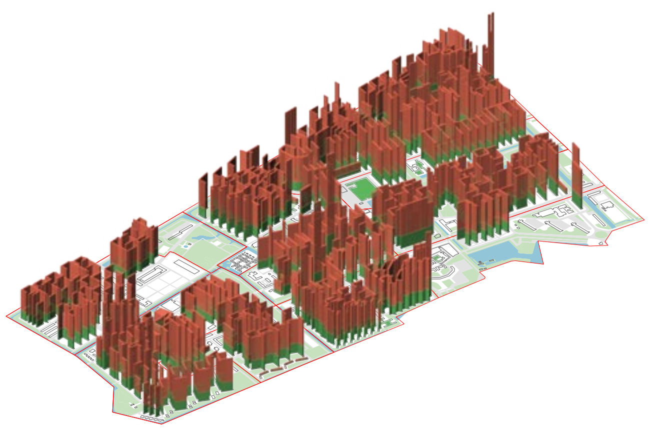


Figure 4.1: Isometric map of potential energy savings for building block built before 1970

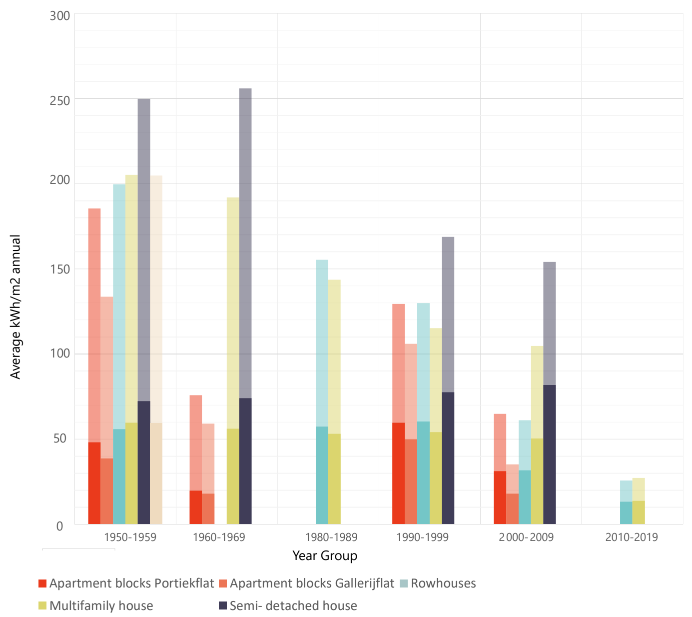


Figure 4.2: Graph showing benchmark energy-savings by building typology and year group

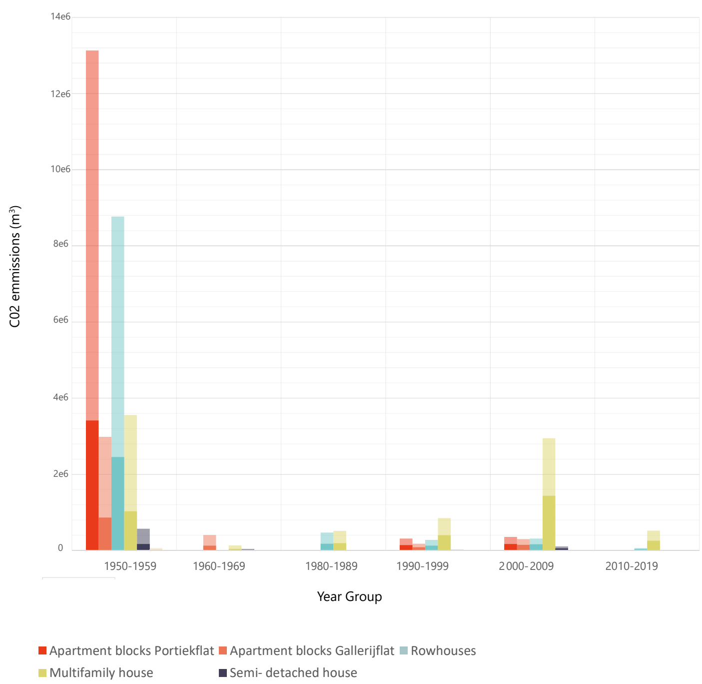


Figure 4.3: Graph showing benchmark C0² reduction per building typology and year group

DENSIFICATION POTENTIAL

In this part of the analysis the Top-up and Fill potentials are examined for the area. The Top-up potential study was possible using the data collection of typologies in the context analysis, whereas the Fill potential required a small design exercise. The densification potential is measured using unit of area (m2) rather than number possible dwellings, as dwelling sizes different between different typologies making it harder to compare the potentials between different building typologies.

- Top-Up Method

  This analysis assumes that a flat roof of a building built after 1950s constitutes a potential for at least an extra storey to be added on top. Using the data collection of the context analysis these assumptions were inputted to provide the desired results.

- Fill Method

  Open block typologies were identified in the area and categorized according to their building typology. Consequently a design exercise determined how much potential space could be 'filled' in-between blocks or on the sides of blocks. Careful attentions was lend to not obstructing access routes or existing windows.

Top-Up Potential

In Figure 4.4 all the building blocks that comply with the Top-up method are highlighted. The flat roof's surface area was used to constitute as the potential available space for new dwellings. A total of 203111m2 of potential top-up space exists in the research area, which could provide space for thousands of new dwellings. The resulting distribution of the total space for each building typology is shown in Figure 4.5. As can be noticed, Rowhouses and Portiekflats from the 1950's have the largest amount of potential space with 49200m2 and 40100m2 respectively. Multifamily houses, especially from the 1990 to 2010 have a relatively high estimated potential.

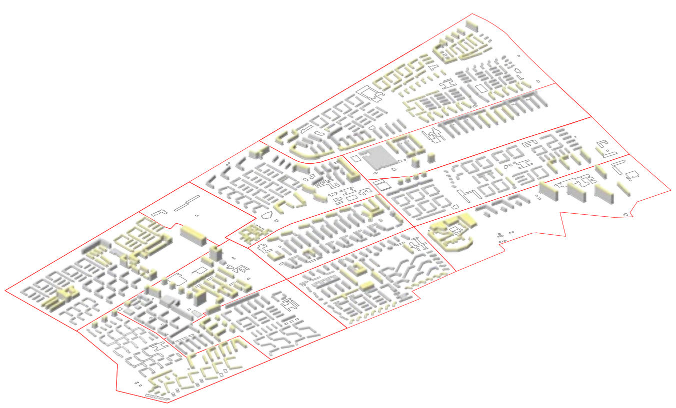


Figure 4.4: Isometric map showing Top-up building blocks location

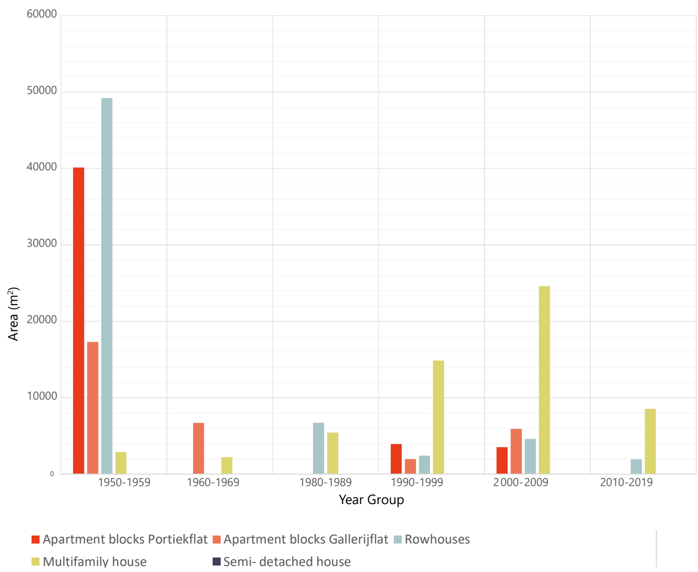


Figure 4.5: Graph showing Top-Up potential per building typology (m^2)

FILL Potential

The open-block typologies that were identified are summarized in Table 4.2 with their corresponding index number and Figure 4.7 illustrating their location in the research area. The typologies only include Portiekflat, Rowhouses and Multifamily house, the semi-detached and detached houses, by nature of their typology don't allow a Fill strategy as surrounding area is private. Nevertheless, a total potential of 5636m2 was found in the area. The most open-blocks identified corresponded to rowhouses, which demonstrated the most space available for this strategy with 3347m2, this primarily includes unused space in corners were two set of blocks are meant to reach. Presumably the mass standardization of the 1950s of these buildings did not include a corner building type.

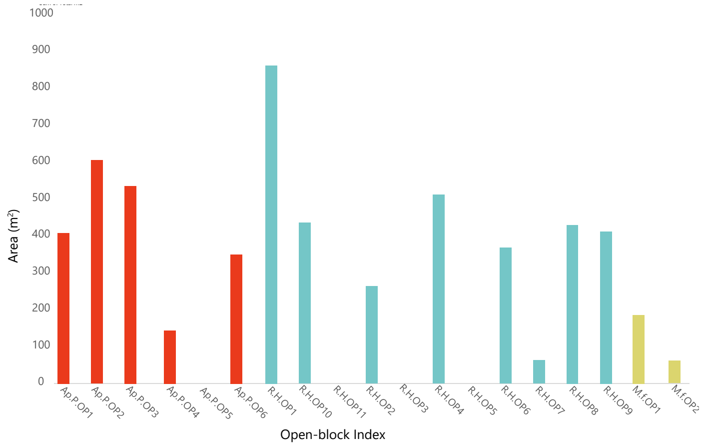


Figure 4.6: Fill potential for each open-block typology

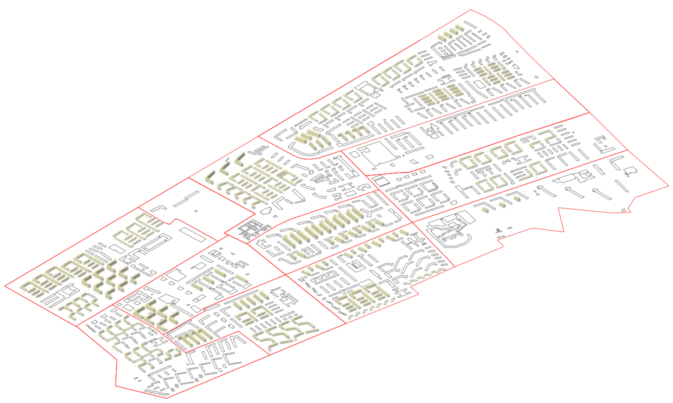


Figure 4.7: Isometric map showing Fill building blocks location

PORTIEKFLAT	*ROWHOUSES*	*MULTIFAMILY*
Ap.P.0P1	R.H.OP1	M.F.OP1
Ap.P.0P2	R.H.OP2	M.F.OP2
Ap.P.0P3	R.H.OP3	
Ap.P.0P3	R.H.OP4	
Ap.P.0P4	R.H.OP5	
Ap.P.0P5	R.H.OP6	
	R.H.OP7	
	R.H.OP8	
	R.H.OP9	
	R.H.OP10	

Table 4.2: Open-block catagorization

These spaces of, which can be specifically found in block typologies like R.H.OP1 or R.H.OP6 for example, tend to have a simple construction that acts as storage for the rowhouses but for the most part they don't provide any other urban utility.

Similarly with the open-block typologies corresponding to Portiekflats, the most space was found in corners between blocks like in Ap.P.OP1 and 3, totalling 2043m2. The most block types found in the area for Portiekflats are Ap.P.OP2 and 3 with 39 and 11 blocks respectively, which contribute the largest potential for this typology, see Figure 4.6. These are not specifically an open-block as they consist mainly of a free standing block with a lot of public green space around. When examining the potential for 'filling' these blocks, it was not always possible due to pedestrian walkways and roads. However, due to the high number of these types of blocks in the area, there is opportunity to extend the block to create new dwelling in some cases. Lastly, the open-block for multifamily houses has the least amount of potential, with only 246m2.

DENSIFICATION RESULTS

When comparing the results of both densification potential studies it becomes apparent that Top-up renders a much higher result than Fill. The Top-up strategy achieves a potential in the hundreds of thousands meter-squared, whereas Fill only dwells in the thousands of meter-squared. This difference is best illustrated in Figure 4.8, were the total densification potential for Top-up and Fill is charted along with the dwelling area for each building typology. However, given the scale of the graph it is not possible to see the Fill area added compared to the existing area. Such a difference in results between the two strategies is too be expected, as Top-up assumptions only require a flat roof space, whereas the other strategy involves a more meticulous approach to identify potential space. In other words, it primary variable, the potential space between building blocks, is much rarer than the abundant potential space offered by flat roofs. Many buildings had a potential for both strategies to be implemented but these are also infrequent. Therefore, this design of a retrofit measure for this thesis will carry forward with only focussing on the Top-up strategy; the concluding factor for omitting case-study research for Fill in the literature review.

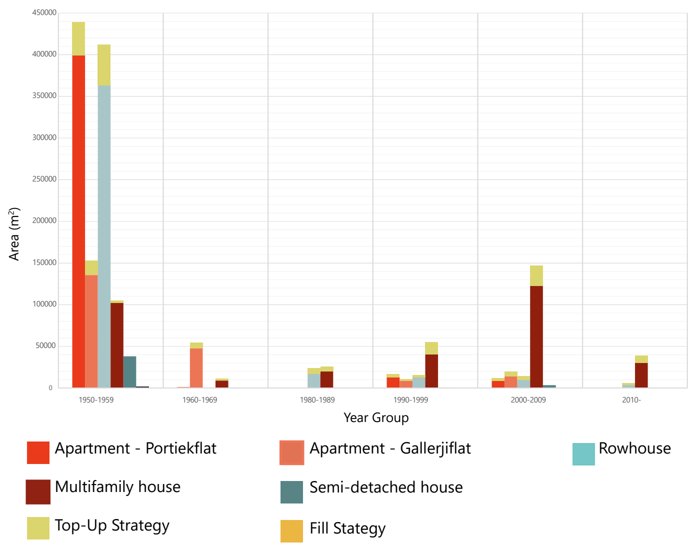


Figure 4.8: Graph showing densification results in relation to existing dwelling area per building typology

THE SUITABLE TYPOLOGY

Both sets of the potential analysis for energy-savings and densification point to 1950's Portiekflat and Rowhouses. The C02 emission reductions favours Portiekflat with a 25% potential for reduction compared to the 17% approximately of Rowhouse, which score better in terms of topping-up by 9100m2 more space than its counterpart. However, with 75% of the 16743 dwellings of the representative area belonging to the social housing sector, it is clear that the retrofit design should tailor to the interests of the social rental stakeholder. Therefore, the top-up and C02 emission results were filtered to only include the building blocks containing 12557 dwelling units belonging to the social rental group. These are illustrated in Figure 4.9 and 4.10.

By only looking at social rental buildings it becomes clear that 1950's Portiekflats have the greatest potential emissions reductions and topping-up potential, as a significant portion of rowhouses are in the owner-occupied stakeholder group. With these final graphs, the most suitable typology for the development of a retrofit design that targets both energy-savings and densification can be established as the 1950's Portiekflat.

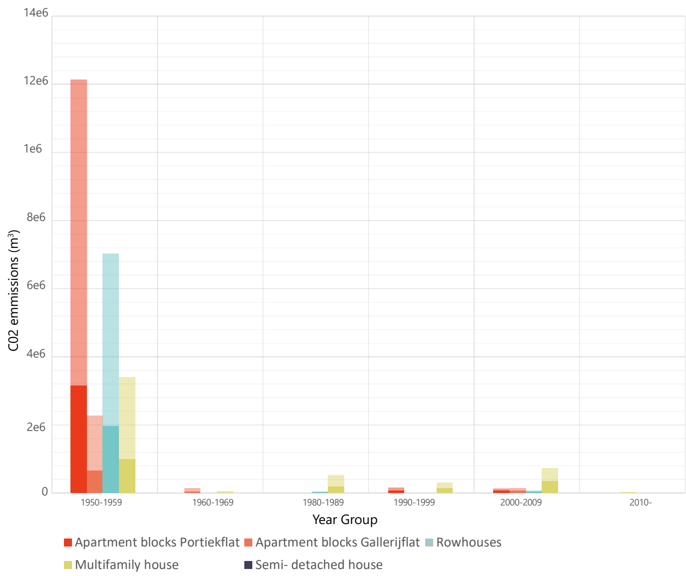


Figure 4.9: Graph showing benchmark C0² for social rental buillding typologies

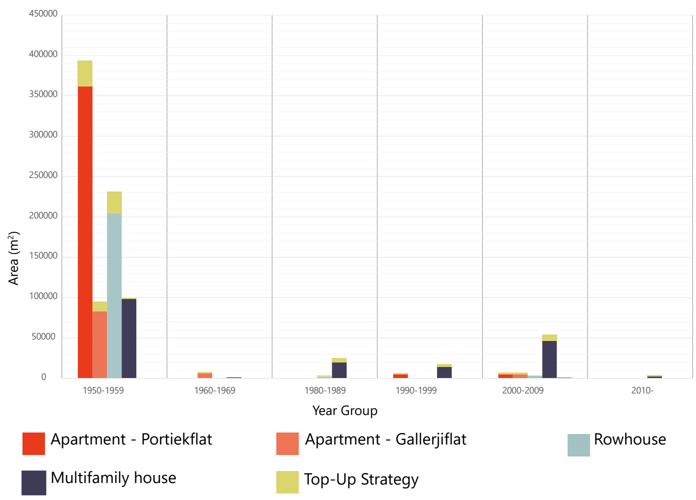


Figure 4.10: Graph showing Top-up potential in relation to existing dwelling area for social rental

The final chapter of the thesis aims to answer the first have of the research questions: "How can the design of a retrofit measure provide integrated solutions to energy reduction and densification for 1950s Portiekflats (the suitable building typology) in Amsterdam Nieuw-west."

Completion of this objective will not only result in the final product of a retrofit design for a specific Portiekflat, as a case-study building but also through the design development of the retrofit design a decision-making tool that provides integrated solutions for densification and energy reduction using certain design assumptions and requirements. Having already identified the most suitable building typology, this step attempts at providing a tool that demonstrates different solutions for differing constraints showing how they might be integrated with one another in a systematic method. Given this tool, the thesis hopes that the stakeholder, in this case, the social housing cooperation, might then apply it to their stock of Portiekflats to identify a viable design strategy to reduce the energy consumption as well as provide more dwelling units.

This chapter is systematically structured to show the detailed steps in the design development. It commences with a building analysis of the existing state of the case-study to understand what existing constraints and opportunities are available. It can then progress to the design criteria where the targets, which is primarily based on the results of the literature review. Using the design criteria, the design consideration can then be explored in the design development phase. These include dwelling layout, energy performance, structure, accessibility and building services. The continuous feedback loop between the design development and the design decisions will aim to deliver the flowchart that demonstrates how decisions based on the design considerations influence the retrofit approach and the creation of the final design. Within the design development, the use of Uniec 2 will be used to verify whether the retrofit measures meet the targets set out in the criteria for the energy performance aspect of the design. Uniec 2 is an energy performance calculation software, in line with current Dutch Regulations, to ensure that EPC of new and retrofitting buildings conform with the energy regulation.

DESIGN METHODOLOGY

The design methodology is structured to support the answer to the main research question regarding the design of a retrofit measure and developing the design tools that demonstrate different integrated solutions for energy reduction and densification. Considering the design aspects for both energy retrofit and densification identified in the literature review which is organized as follows: Energy performance

- Structure
- Accessibility
- Housing Quality
- Construction
- Building services

These aspects have to be explored using the case-study building chosen to identify the various solutions behind them and how they can be integrated to provide design solutions. However, it is clear the listed design aspects need to be prioritized and to organized at different design scales. The first priority is the consideration of the energy performance of the building, the essence of the thesis follows the logic that with such a large proportion of the existing building stock needing urgent deep energy retrofit, there should stand an opportunity to densify in an every growing urban climate. Consequentially, the first priority lies in identifying appropriate retrofit measures for the building typology, using the literature results, namely, energy standards, prescriptive values for building elements as target requirements. These measures will be validated using Uniec 2, an energy performance standard calculation software that complies with the Dutch regulation (NEN 8088 and 1068).

Secondly, the considerations that follow the energy performance aspect are the top-up design aspects which include structure, accessibility, construction and building service. Here is where a differentiation must be made in terms of design scales, both the structural and accessibility aspects have an overarching influence in the final design and in the feasibility of the top-up, in which construction and building service considerations come secondary. The construction solutions cannot be resolved first with having considered whether the existing structure is even capable of supporting it or how the spatial arrangements will allow for appropriate access.

With this in mind, the aspects energy performance, accessibility, and structure will be explored using the case-study building, to develop different approaches for each, identifying the design-decisions behind them, and examining how the can combine with one another. The product of this exploration will lead to the compilation of all the various approach to form a toolbox of approaches in which the decisions behind them will be packaged in the form of a decision-making tool and the resulting combinations create the design brief strategy. This will provide the central interventions necessary for energy-reduction and topping-up with further suggestions to improve overall housing quality of the building block. Following this step, is the case-study design that further explores the construction and building service aspects as well as the energy performance of the new dwellings.

The very first exercise in the methodology is to survey the chosen case-study building to gain a better understanding of the existing constraint which relates to layout, construction and energy performance. This will provide not only the bases for the final retrofit design but also a generic Portiekflat model that allows the exploration of approaches for the primary aspects for top-up (structure and accessibility).

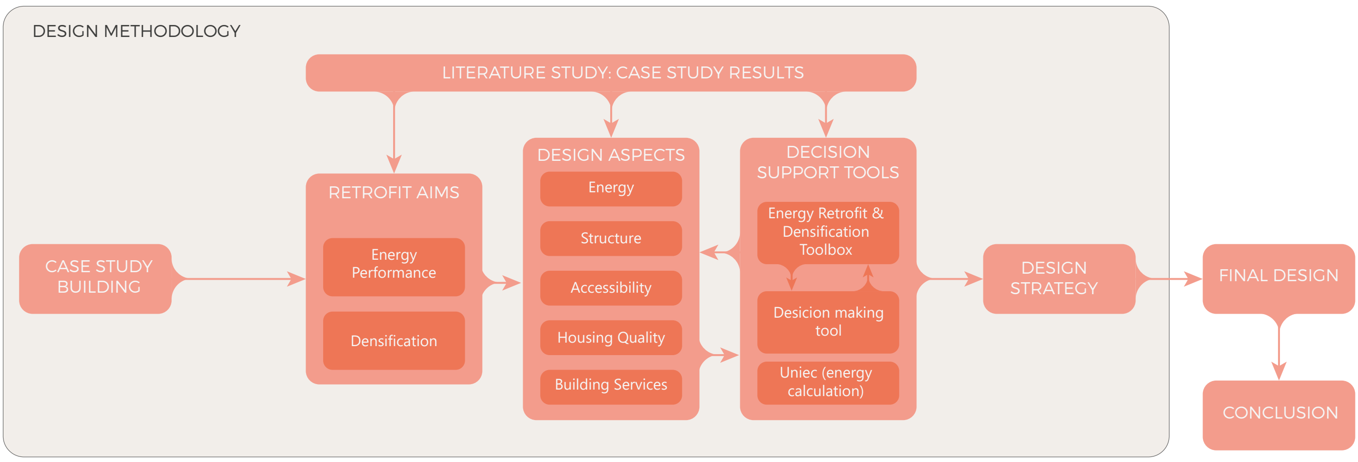


Figure 5.1: Design methodology diagram

CASE STUDY BUILDING

As a representative of the most suitable typology, the portiekflat on Bouwen Erwoutszstraat was chosen because of its high energy saving potential, Top-Up potential capacity and belonging to a social housing cooperation – Stadtgenoot. This section provides the building analysis of the existing state of the building, elaborating on the constraints and opportunities in terms of its layout planning, construction, structure and energy performance. This was made possible by being able to retrieve most of the original drawings for this residential complex, which included many drawings of the case-study building from the online archive of the municipality of Amsterdam. This analysis, subsequently, provided more insight into the typology in general so as to create a generic model for design development.

The architects in charge of the project was none other than Van den Broek & Bakema Architects, now formally known as Broekbakema, a leading architecture practice in the Netherlands. During this period, this residential complex was a very common place design, characterised mainly by the construction speed and capacity to alleviate the housing crises after the war. The building is part of a whole complex that was constructed to include different residential typology, most of them being categorized as portiekflats or gallery-flat.

Figure 5.2: Street view of case study building (google maps)

The Stakeholder

As mentioned previously, the block, as well as almost all the blocks in that complex, are owned by Stadtgenoot. As a social housing provider, one of the largest in the Netherlands, is core objective is to provide affordable housing to households with a low income through a supply of 29,916 dwelling. Past experiences have taught them that their customer demographics varied from single young people to large families and that their core supply in many cases did not provide the sufficient diversity to accommodate the different groups. Moreover, the company is under pressure by the municipality to achieve various goals over the coming years, including providing more affordable housing to the city of Amsterdam and upgrading their stock to an average EPC label C by 2020, effectively requiring all labelled buildings with EPC of F, G and half the stock labelled E, to be upgraded to an EPC label B. This amounts to a total of around 4000 dwellings, a lot of which are Portiekflats. This has led to the cooperation adopting a strategy of using sales, liberalization and even demolition to reduce its core supply to 26500 dwellings as shown in Figure 5.3, to gain the capital necessary to be able to financially support new construction project and retrofits (Anderlesen, 2016).

Regarding the specific case-study building of these thesis, it finds itself in an identified area for renewal that

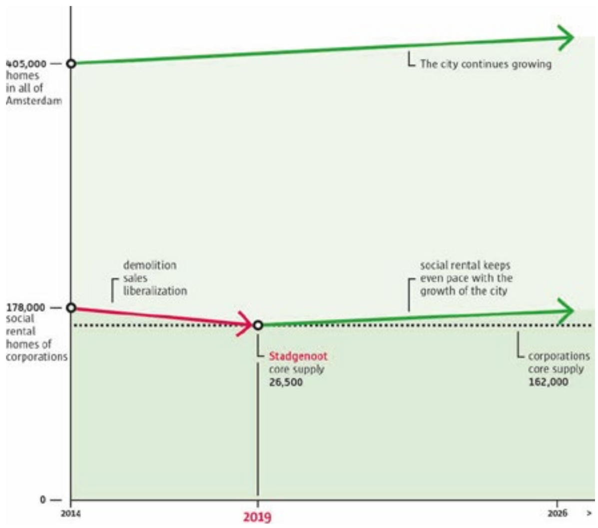


Figure 5.3: Graph showing Stadtgenoot's building stock strategy (Anderlesen, 2016).

Staatgenoot wants to focus on in the coming years. The area of Nieuw-West has been scored with a low liveability rating compared to the rest of Amsterdam's districts, shown in Figure 5.4, and with such a large stock of the buildings being owned by social housing cooperation, a significant portion of the responsibility for its renewal falls into their hands. The renovation of these buildings will play a key role and provide sufficient opportunity for reducing energy demand in the area and densifying, as demonstrated in by the analysis in this thesis. Moreover, as part of their renewal strategy for the immediate future, is their acknowledgment that they have to build smaller one to two person households in centrally located areas like Nieuw-West and accommodate larger families in the outskirts, were restructuring area offer better family amenities. This provides the thesis with enough indication as to what type of dwelling the top-up could accommodate, which will be discussed further later sections.

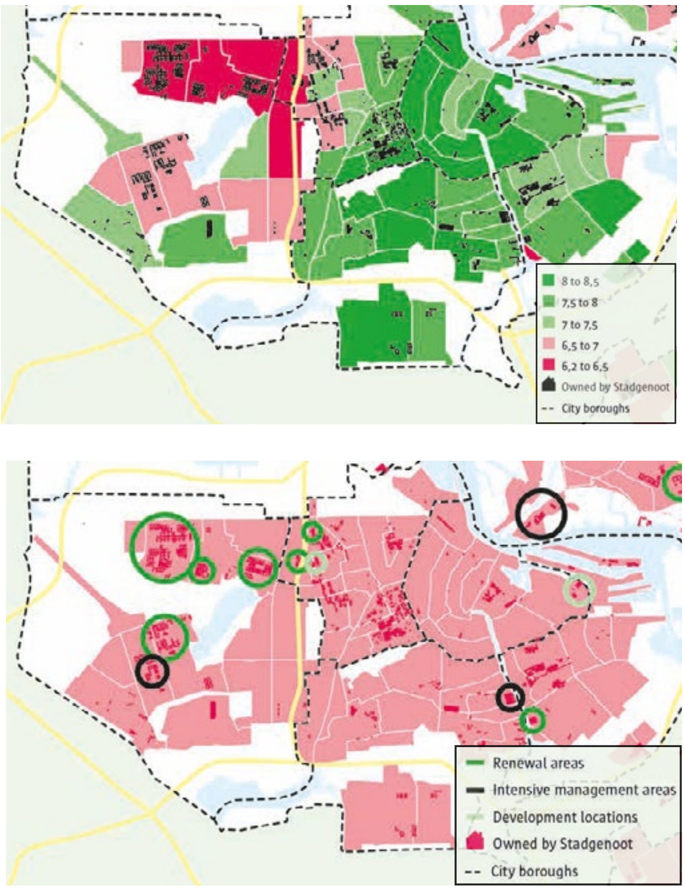


Figure 5.4: Top map shows livability scores according to Amsterdam district. Bottom map highlights strategic areas (Anderlesen, 2016).

Existing Layout

The block in contention is part of a large complex that was constructed in the 1950's, the specific building having been completed in 1956, and now stands in a strategic redevelopment zone identified by the municipality of Amsterdam for densification. The four-storey building contains a total of 32 dwellings divided over 4 adjoining block, each with its own access core in the centre that provides vertical access over its 4 levels with a half-landing staircase. The ground floor being used as a storage space by the dwellings. From the floor plan (Figure 5.5), the two distinct but outdated dwelling types are illustrated, one two and the other three-bedroom apartment, which due to the nature of construction follows a very divided and narrow spatial arrangements with each space connected by a central hallway. Each dwelling has access to one toilet and one narrow bathroom that is accessed through the kitchen, as well as a balcony that compliments the dining/ living room area. In general, the arrangement of these dwelling spaces and their dimensions would be deemed too restrictive for modern standards but are in fact characteristic of the time as structural limitations in the method of constructions only allowed for these narrow floor spans during the developmental stages of these mid-storey high novelty dwellings.

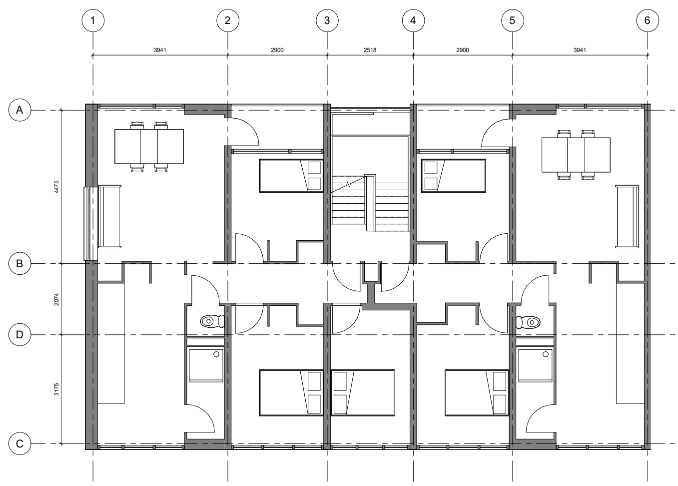


Figure 5.5: Bouwen Erwoutszstraat typical floor plan of block unit .

Existing Energy Performance

The energy performance of this block was already examined in the previous chapters, using the gas and electrical consumption data of 2012. It showed a consumption for heating at 171kwh/m2 and electricity at 47kWh/m2, with an overall energy performance estimate of label F. This information is vital for verifying the digital model on Uniec 2, so that during the design stage, the effectiveness of different retrofit measures can be assessed in terms of achieving the energy targets.

For this exercise, the U-values of each different building element was calculated, presented in Table 5.1, using the existing drawings from the archive. The total energy consumption estimated using the software resulted in 226.3kWh/m2 compared to the total 218 kWh/m2 from the data of 2012, a good validation with only roughly 3% deviation from the real data in the software model. For the full results from Uniec see Appendex C.

Thermal Envelope	Building Component	Area ($m^{2)}$	U-value (W/m^2K)
West			
	Wall Type 2	124.6	2.08
	Wall Type 3	202.7	1.33
	Wall Type 4	114.0	3.44
	Glazing	441.8	5.80
	Opaque panels	156.2	1.56
East			
	Wall Type 2	124.6	2.08
	Wall Type 3	209.2	1.33
	Glazing	409.1	5.80
	Opaque panels	190.9	1.56
North			
	Wall Type 1	112.4	1.75
	Wall Type 3	26.4	1.33
	Glazing	5.1	5.80
South			
	Wall Type 1	112.4	1.75
	Wall Type 3	26.4	1.33
	Glazing	5.1	5.8
Roof		657.6	2.08
Ground Floor		657.6	5.00
Uniec Results			
energy demand ($kWh/m^2/a$)		213.5	

Table 5.1: Input values for Uniec. Calculated U-values based on construction drawings

Figure 5.6: Case-study Elevations

Existing Construction

At the time of this buildings conception, mass accommodation projects were underway and in huge demand, spawning the development of new construction methods to deliver rapid, standardized dwellings. The 1950's Portiekflat-blocks exemplify some of the transition from traditional construction methods, including loadbearing brick walls, to industrialised prefabricated building elements. The case-study on Bouwen Erwoutszstraat demonstrates a blend of tradition with contrasting new methods, illustrated in Figures 5.7 and 5.8. An in situ perimeter concrete wall outline the external ground floor, which surrounds transversal concrete block walls that mark the structural grid for the upwards stacking of a combination of prefabricated building elements and on-site workmanship. The floors mainly comprise of a hollow core slab, known as 'Beton Armé Sans Coffrage' (reinforced concrete without formwork), essentially a hollow concrete beam with a cross-section shaped like a semi-circle. These beams were laid out and covered in in situ concrete to create the floor. As a product they offered different dimension depending on the span and the load, which for a standard residential load meant a span that varied between 3.5 and 4.5m, with thickness varying from 12cm to 26cm (Van de Voorde , Wouters, & Bertels, 2015). The facade is made up primarily from two different construction elements, a cavity wall construction, which utilizes prefabricated concrete elements, known as 'korrel beton,' a granular concrete that in many cases mixed debris from buildings that were destroyed during the war, and brickwork. The second element includes prefabricated wooden panel constructions that accommodated the glazing of the building.

1. External wall construction: 103mm brickwork; 53mm cavity; 193mm granular concrete
2. Floor construction: flooring; 22mm screed; 160mm hollow core slab
3. Roof construction: 2 layers of bitumen; 27mm wood board; 180mm timber beams, anchored with steel wire; 50mm concrete-wool ceiling
4. in situ concrete junction
5. Single glazing framed in wooden frame
6. Concrete perimeter beam: 400x 335mm
7. 150mm in situ concrete wall
8. Ground floor: 200mm in situ concrete floor slab

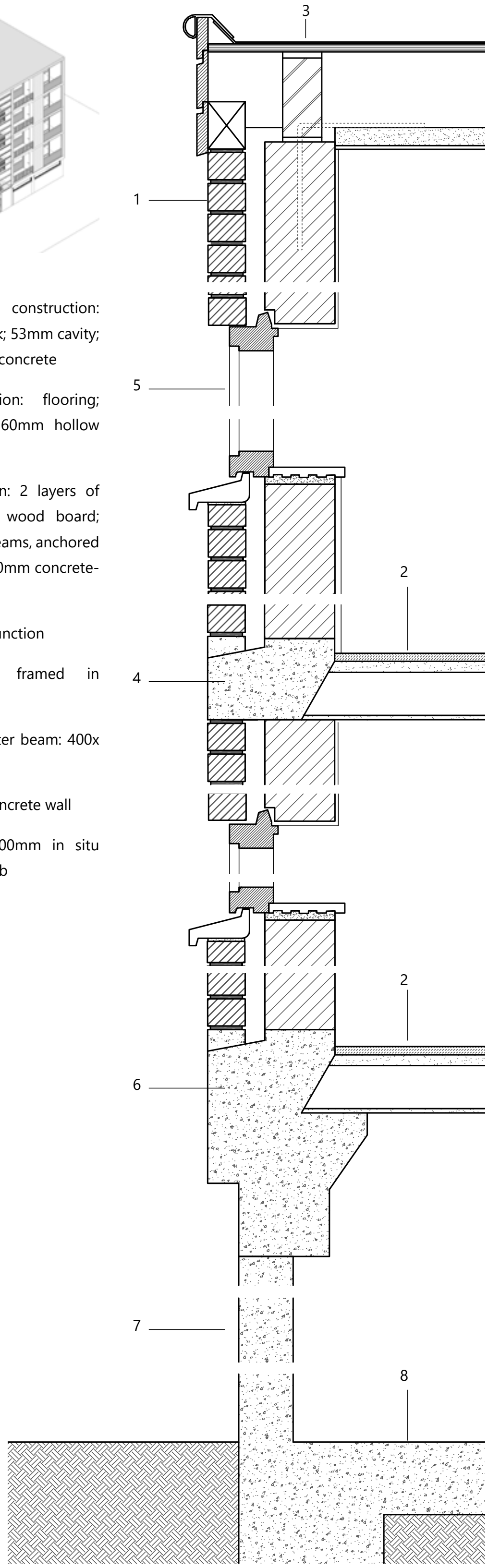
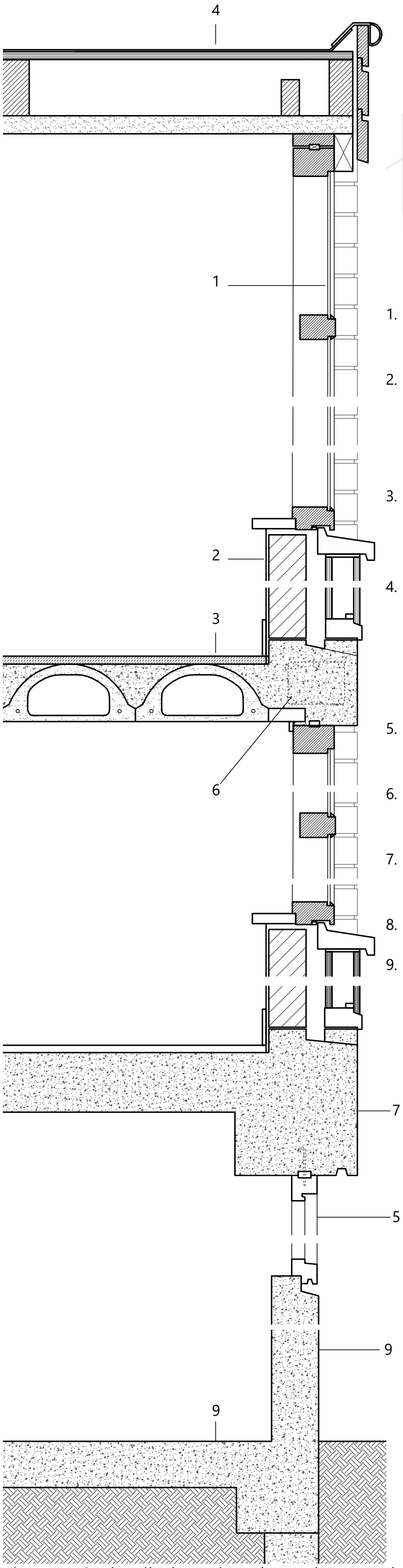


Figure 5.7: detailed section through north elevation (1:20) redrawn from archived drawings.



1. Single glazing in wooden framed panel
2. External wall construction: 95mm of wooden board construction; 50mm cavity; 103mm korrel beton
3. Floor construction: flooring; 22mm screed; 160mm hollow core slab
4. Roof construction: 2 layers of bitumen; 27mm wood board; 180mm timber beams, anchored with steel wire; 50mm concrete-wool ceiling
5. Single glazing framed in wooden frame
6. in situ concrete junction with reinforced steeld
7. Concrete perimeter beam: 400x 335mm
8. 150mm in situ concrete wall
9. Ground floor: 200mm in situ concrete floor slab

Figure 5.8: detailed section through west elevation (1:20) redrawn from archived drawings.

Existing Structure

The structure of the building relies on the loadbearing transversal walls relative to the long side, which transfer the loads from the in-between spanning floors down to a corresponding concrete beam that further distributes the load to 4 or 5 piles, totalling to 100 piles for the whole building. According to the structural drawings, a portion of which is shown in Figure 5.9, of the foundations, each pile has an allowable bearing capacity of 50 tons with a calculated present load of 40.7 tons with an additional negative stick load of 10.7, effectively bringing the piles to their maximum structural capacity. The negative stick on the pile is a downward force of the soil acting on the pile, which occurs when the pile does not 'hit' hard soil but remains in the relatively softer soil.

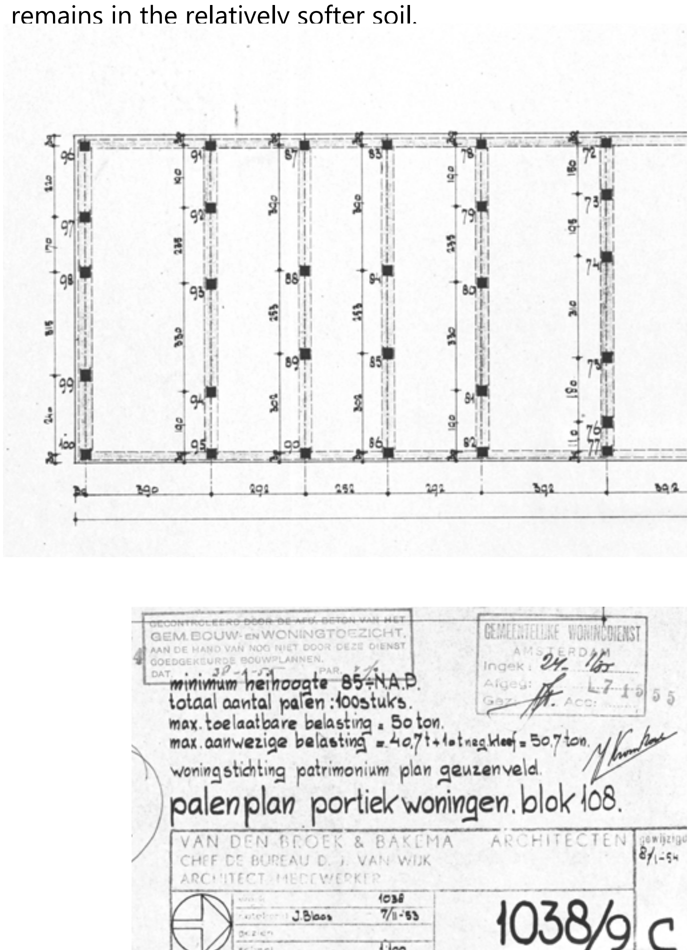


Figure 5.9: Portions of the structural foundation plan for Bouwen Erwoutszstraat. Top image shows a portion of the foundation plan; bottom image the structural pile capacity.

GENERIC MODEL

In the next design stage, improvement of the energy performance of the existing building will be explored, followed the top-up design approaches which for the general design strategy brief, include the design aspect of structure and accessibility. Using the case-study, a generic model representing the general portiekflat characteristics was made in order to quickly explore different approaches for these aspects. The model consists of a single block inspired from the case-study building, containing a total of 8 dwelling over 4 levels that is accessed from on central circulation core (see Figure 5.10 which presents an isometric of it).

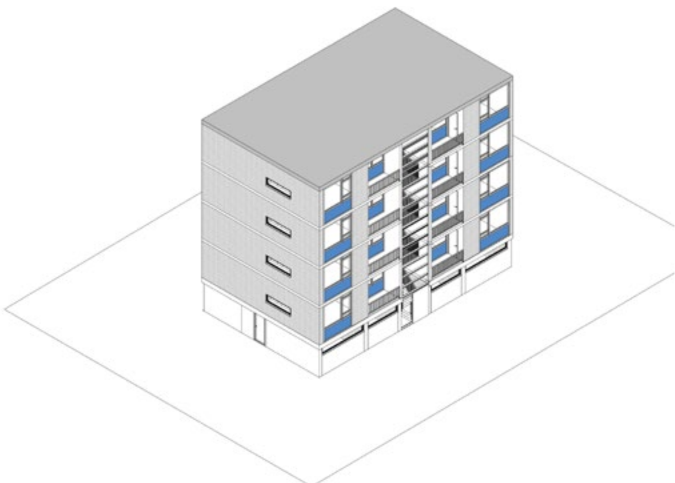


Figure 5.10: Isometric view of generic model of Portiekflat typology

RETROFIT MEASURES

Energy Performance

The first design task is to identify the retrofit measures required to achieve certain energy standards for the Portiekflat typology. The literature results showed that deep retrofits between 60-90% would be required to tap in the saving-potential to really impact our C02 reduction. Retrofitting old and existing building to current standards was shown in Tabula to render an energy reduction of at least 70%, achieving the required energy reduction. The energy standards have since moved up since the publishing of the Tabula results from an EPC of 0.6 to 0.4, making retrofits targeting this grade much more likely to save more energy. Therefore, one retrofit scenario will look at achieving an EPC of 0.4. As mentioned before, the more realistic pressures acting on the social housing cooperation, like in this case Staatgenoot, is their commitment to bring the average of their building stock up to an EPC label C by 2020, which essentially translates to retrofitting all their Label G and F stock, totalling 2700 dwellings, and half of the label E's, another roughly 2300 dwellings; this represents about 17% of their stock, a high number of these being Portiekflats, with a high likelihood of seeing energy performance improvements.

This part of the design development will use the retrofit toolbox that was compiled in the PhD research 'Façade Refurbishment Toolbox' (Konstantinou, 2014), shown in Table 2.4. Using this toolbox, the aim is to compile a retrofit toolbox specifically for 1950's Portiekflat's after having selected the measures needed for achieving the two target levels. These measure will be verified using the already validated model of the existing case-study on Uniec 2.

EPC Label B

The main questions for this design exercise were:

- What retrofit measures offer the least amount of intervention given the building envelope elements?
- What opportunities do the existing building envelope element provide to allow minimal intervention?

Given these questions and the investigation into the existing condition of the building it was possible to propose some reasonable measures to achieve an EPC label B. The first building element considered was the external wall, of which there are a total of two types. Cavity wall construction and solid wall construction on the ground floor. Using cavity wall insulation, a measure which only requires drilling a hole into the mortar of the brick outer-leaf and injecting the insulation into the cavity, it was possible to improve the wall from an average U-value of 1.92 to 0.57W/m2K. The main glazing elements, which are made out prefabricated panel constructions can be replaced relatively easily for new better performing panels that contain the same ratio of glazing to opaque elements as the replaced one, but with double glazing (1.80 W/m2K) instead of single and higher performing opaque elements (0.24 W/m2K). Since the roof is made up of wooden beams, the space in-between can be exploited to accommodate ridged insulation panels, the depth available for the insulation is about 250mm, allowing for a substantial improvement in the roofs performance to 0.16 W/m2K, a jump to current new-build standards. Building services are improved by replacing the conventional gas-fired boiler with a more efficient combi-boiler, a retrofit

EPC: B (1.20)			
BUILDING ENVELOPE	*EXISTING CONSTRUCTION*	*TARGET (W/m²K)*	*MEASURE*
1. External Wall	1. Cavity wall - 103mm brickwork, 54mm cavity, 193 concrete wall	0.54	Cavity wall insulation
	2. Cavity wall - 100mm brickwork, 50mm cavity, 150mm concrete wall	0.59	Cavity wall insulation
	3. In situ concrete wall 250mm	1.33	No measure
	4. Balcony walls	3.44	
2. Window	1. Single glazing	1.80	Replace with double glazing
	2. Operable single glazing	1.80	Replace with double glazing
3. Balcony	1. Continuous concrete floor slab with no insulation		Insulate surrounding wall constructino
4. Roof	1. Wooden beams	0.17	
5. Ground Floor	1. Concrete slab on ground, no insulation.	5	No measure
BUILDING SERVICES	*EXISTING SYSTEMS*		
Space Heating	Conventional boiler		HR-107 Boiler
Domestic Hot Water	Conventional boiler		Combi system with boiler
Ventilation	Natural		Natural
ENERGY REDUCTION			*52%*
PRE	*213.5 kWH/m²*		
POST	*112.1 kWH/m²*		

Table 5.2: retofit measure summary with Uniec result for EPC B

measure commonly used as demonstrated in the case-study research. All these measures are summarized in Table 5.2.

In-putting these values into Uniec 2, the software showed that, indeed, these measure bring the overall energy performance from a label F to a B, without application of a retrofit measure to the ground floor and in situ concrete wall of the ground floor.

EPC Label A++

The jump to a label A++ level of energy performance certification, not only requires substantial increases in U-value of the building envelope but also a more rigours employment of retrofit measures that work in conjunction with one another so as to reduce infiltration and eliminate thermal bridges. The latter solutions having to be explored further in the later stages of the retrofit design when the approaches for the different design aspects have been identified. This section will aim to answer the following question:

- What retrofit measures (passive and active measures) can be used to upgrade the case-study building to a EPC label A++

Using the results from the case-study research the most effective method of achieving higher targets is a wrap approach in which the outer-leaf of the construction is retrofitted to provide the necessary U-values as well as the elimination of thermal bridges and low infiltration rate.

There a couple of options when it comes to the external wall for the two main wall types, as shown in Figure 5.11, which include:

Wall type 1: cavity construction

1. Cavity fill insulation with an external insulation with finishing system (EIFS)
2. Removal of outer-leaf (brickwork) to accommodate (EIFS)

Wall type 2: solid concrete wall

1. Addition of EIFS

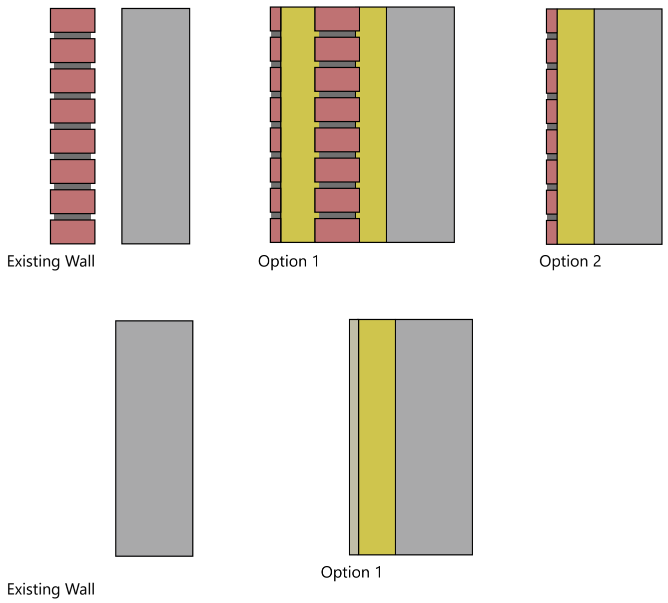


Figure 5.11: External wall retrofit options

The removal of the outer-leaf brick wall is a preferred intervention as it keeps diminishes the overall depth of the external wall unlike the other option. Makes it much easier to improve infiltration as an airtight layer can be applied between the new and old parts of the wall and the thermal line of the building envelope can be kept unbroken much easier without the existing outer-leaf.

Concerning the ground floor insulation, unlike in the other set of measures, it has to be addressed to successfully achieve energy performance requirement. In the case of Portiekflats, as shown by the case-study research and the case-study building in this chapter, there is simply no space or way to apply a layer of insulation either underneath of above the ground floor, as in one case its simply inaccessible given the solid concrete floor and in the other case it would un-level the entrance. Therefore, the only option is to apply insulation underneath the first floor and keep the ground floor as an unheated space.

The results of these measures are illustrated in Table 5.3, the specific target of 0.4 EPC was not possible to reach without the inclusion of renewable energy sources, either solar or photovoltaics on the roof. However, a close score of 0.5 was achieved which reflects an 81% reduction in energy consumption of the building.

Retrofit Measures Conclusion

Both sets of targets show substantial energy reductions compared to the existing energy-consumption and provide very viable levels of interventions to achieve this reductions. Even considering minimal reductions, the corresponding minimal retrofit measures can halve the energy demand, a proposition that might be deemed very attractive to a social housing cooperation that, by nature of the affordable housing industry, a restricted budget.

The more elaborate retrofit measures to achieve current building standards do require more attention when being applied to make sure thermal bridges in junctions are eliminated and that the airtightness is reduced to a level that enables the uses of mechanical ventilation with heat-recovery to further the energy-efficiency of the building. However, the simplicity in the stacked construction system of the Portiekflat can make it relatively easier to apply these measures if the outer-leaf of the cavity construction can be removed.

The next design stage will in general look at how the top-up design aspects fit into the equation with the retrofit measures and whether integrated solutions can be offered

EPC: A++ (0.4)				
BUILDING ENVELOPE	*EXISTING CONSTRUCTION*		*TARGET (W/m²K)*	*MEASURE*
1. External Wall	1.	Cavity wall - 103mm brickwork, 54mm cavity, 193 concrete wall	0.22	Removal of outer leaf and application of EIFS
	2.	Cavity wall - 100mm brickwork, 50mm cavity, 150mm concrete wall	022	Removal of outer leaf and application of EIFS
	3.	In situ concrete wall 250mm	0.22	Application of EIFS
2. Window	1.	Single glazing	1.65	Replace with double glazing
	2.	Operable single glazing	0.80	Replace with triple glazing
3. Balcony	1.	Continuous concrete slab with no insulation	0.23	Enclose balcony with panel and glazing construction
4. Roof	1.	Wooden beams	0.17	Infill insulation between beams (mineral fibre, 5.26m²K/W) Replace underside cement board 50mm (0.55m²K/W)
5. Ground Floor	1.	Concrete slab on ground, no insulation.	0.13	Application of insulation underneath first storey floor.
BUILDING SERVICES				
Space Heating	Conventional boiler (gas)			Air heat pump/HR boiler
Domestic Hot Water	Conventional boiler (gas)			HR boiler
Ventilation	Natural			Mechanical ventilation
ENERGY REDUCTION				*81%*
PRE	*213.5 kWH/m²*			
POST	*40.9kWH/m²*			

Table 5.3: retofit measure summary with Uniec result for EPC A++

to complement these two sets of retrofit measures. It will be in the final technical stage where the specific integration will be explored.

PORTIEKFLAT ENERGY RETROFIT TOOLBOX				
BUILDING ENVELOPE	*EXISTING CONSTRUCTION*	*RETROFIT MEASURES*		
1. External Wall 	1. Cavity wall construction: Brick outer leaf, cavity, lightweight concrete. 2. Insitu concrete wall 3. Panel construction: wooden framed panel +single glazing	Cavity wall insulation	Exterior Insulation and Finishing System (EIFS)	Ventilated facade
		Second Facade (single glazing)	Second Facade (double glazing)	Internal Insulation
2. Window 	1. Single glazing 2. Operable single glazing	Replace windows with double/triple glazing	Secondary single glazing	Secondary double glazing
		Install shading device	Enlarge window openings	
3. Balcony 	1. Continuous concrete slab with no insulation	Incoperate balcony into thermal envelope	Insulate balcony slab	Balcony cladding - single glazing or double glazing
		Remove balcony		
4. Roof 	1. Wooden beams 2. Concrete slab	Insulate between structural beams	Insulate flat roof externally (warm roof)	Green roof
5. Ground Floor 	1. Concrete slab on ground, no insulation.	Insulate on top of ground floor	Insulate on bottom of first floor slab	

Table 5.4: Portiekflat retrofit toolbox

ACCESSIBILITY

This design aspect addresses the circulation of the building, specifically how it can be improved and made viable for topping-up. The existing conditions of the typology will characteristically not have an elevator present, which for modern mid-risers of above three storeys is unacceptable, as it actively discriminates against certain demographics from being able to use the building. For social housing cooperation this constraint limits their ability to supply affordable housing to some of the most vulnerable parts of the populations, those who might most need it; currently around 80% of Staatgenoots building stock has no lift present, mind you that some typologies don't require lifts.

For topping-up purposes to provide new dwellings, the addition of lift access is a crucial point that determines the viability of the overall top-up, let alone the improvement of the access to the existing dwellings. The current access arrangement provides the minimum dimensions for circulating, located in the centre of the block, between the shortest spanning grids, it becomes apparent that there is simply a lack of space for the addition of an elevator within the given constraint. See Figure 5.12 for the existing plan of the vertical circulation, it comprises of a ground floor straight staircase followed by half-landing staircases that access between the first and fourth storey. There are a few approaches that can be adopted to overcome this hindrance which have been explored in the following sections.

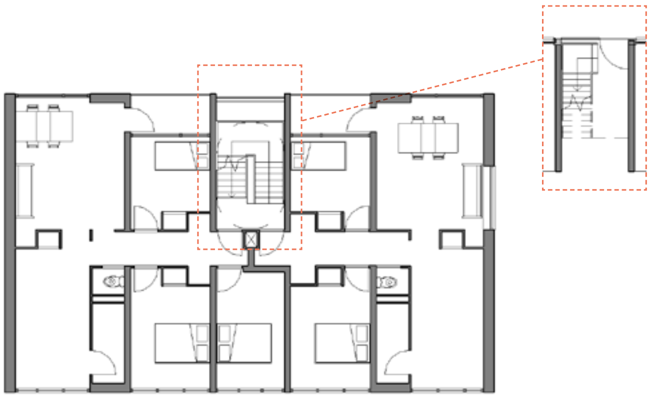


Figure 5.12: Floor plan highlighting existing circulation

Approach 1

The first approach that can be applied is the same on as in Melis Stokelaan, the first case-study for densification, where a complete remodelling of the core took place while sticking to a minimal expansion of it to accommodate the elevator. It requires exchanging the existing half-landing staircase for a straight staircase. There are essentially two alternatives that can make this approach work, shown in Figure 5.13

The first alternative entails providing the entrance and elevator within the same constraints, this requires to installation of a custom elevator that is big enough to service the floors while being narrow enough to provide sufficient access for the entrance. In the second alternative the entrance is offset, thereby creating a bigger lobby area, which provides more freedom in the elevator installation and dimensions albeit reducing the amount of storage capacity of the ground floor.

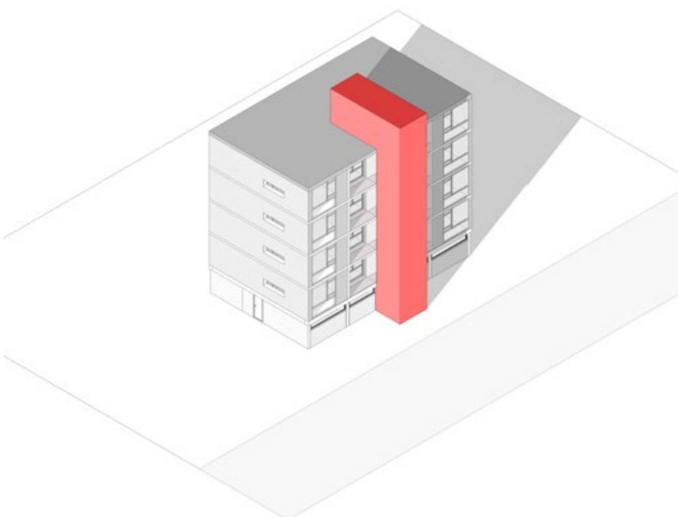


Figure 5.13: Isometric view of approach 1

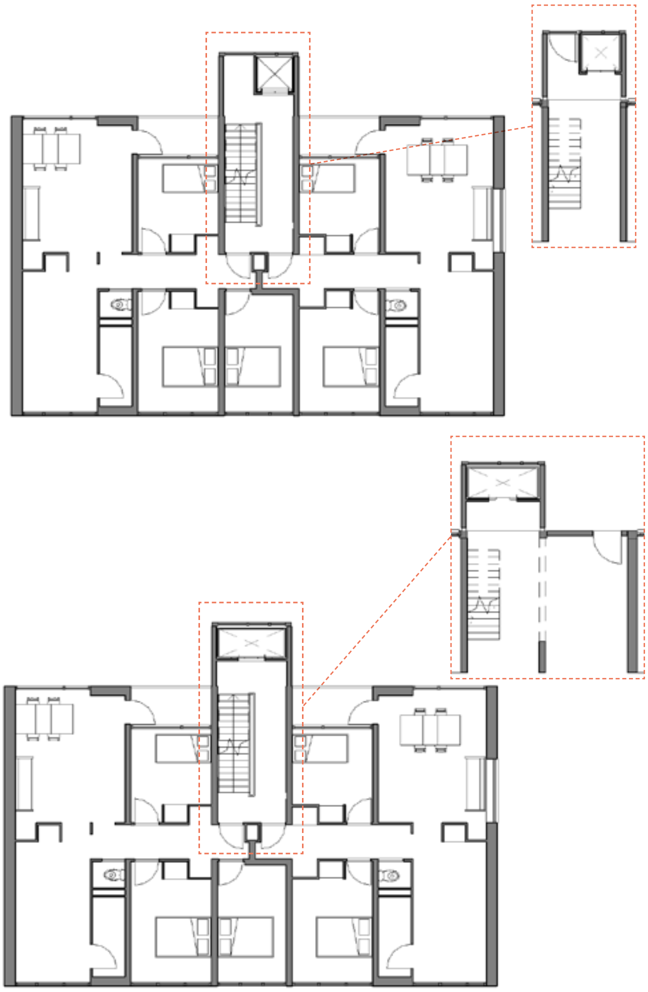


Figure 5.14: Floor plans showing 2 alternatives for approach 1

Approach 2

The second approach that was explored follows the reasoning: if there is not enough external space for the installation of the elevator how else can circulation be improved. If this is the case, then exploring whether adjacent space on the short-end of the elevation can be used to provide a completely new circulation core. The direct consequence of doing this would entail having to provide gallery access to service the new core. Moreover, the question, as well as the opportunity, for what occurs with the previous core needs to be explored. The strength of this type of intervention lies in the ability for one elevator to service more than 8 dwellings from the same block, which might offer greater savings compared to Approach 1 but should outweigh the cost of rest of the interventions needed. These include addition of new galleries, reorganization of existing dwelling space to adapt to new access and the reuse of the previously-used core as presented in Figure 5.16.

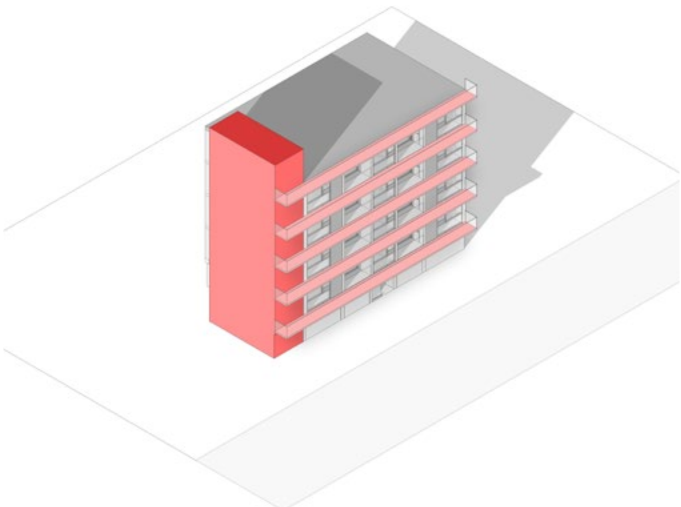


Figure 5.15: Isometric view of approach 2

Figure 5.16: Floor plan for approach 2

Approach 3

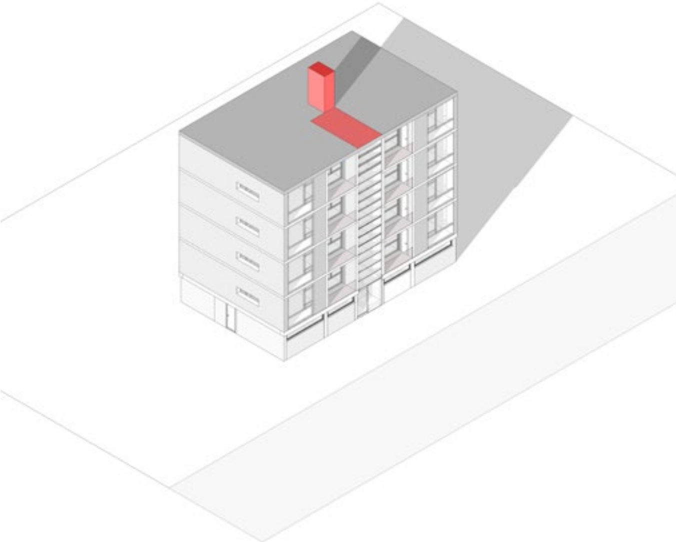


Figure 5.17: Isometric view of approach 3

The third approach explores the scenario if there is no external area to expand to provide the needed space for the elevator. Can the elevator be accommodated within the building envelope? There is a possibility but it requires using some the existing dwelling space, a usually undesirable intervention given the existing dwelling size, together with a minimal reorganisation of the entrance to the dwelling, see Figure 5.18

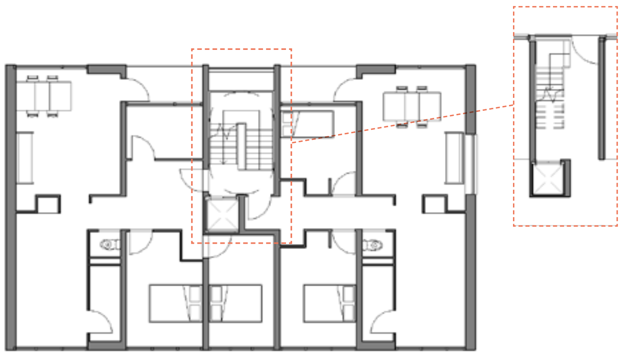


Figure 5.18: Floor plan for approach 3

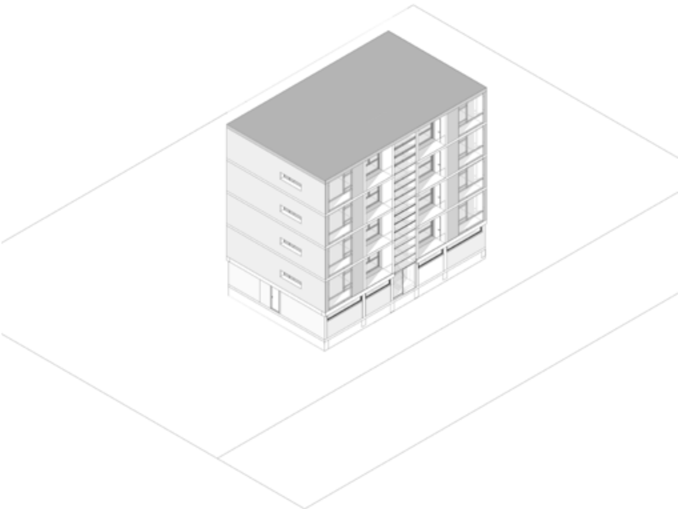


Figure 5.19: Isometric view of approach 4

Approach 4

If no elevator installation is possible, a potential top-up for the purposes of new dwellings is very difficult to justify as it would not comply with building regulations. However, keeping the access unchanged still provides the opportunity for topping-up to augment the existing top-dwellings into potential penthouses. Although not strictly offering the possibility to densify the apartment block, it does allow for diversification of the dwellings available in the block, which can impact housing quality positively.

ACCESSIBILITY SUMMARY	1. Remodelling/extension of circulation core	2. Remodelling to gallery access	3. Internal remodelling of circulation core	4. No change to access
				
DESCRIPTION	Central existing circulation core modified to accommodate new regulations. Half-landing stairs replaced with straight flight and an elevator is installed.	Vertical circulation is offset to side of building, with new stairs and elevator being installed. Portiekflats become assemble via new gallery ways allowing previous circulation space to be converted into dwelling space.	Elevator incorporated into internal layout of building. The elevator would use up existing dwelling space and require some reorganization of dwelling floor-plan. Could require replacement of existing staircase.	No change to current access core
CONDITIONS/REQUIREMENTS	• Sufficient external space in-front of building entrance (min 2.5m) • Replacement of existing half-landing stairs to straight stairs. If flights exceed 16 risers it might require more external space. • Addition of custom sized elevator	• At least 2.5m of space on either side of the Portiekflat. • Gallery access will require at least 1.2m in-front of chosen access route. • Depending on the length of the block, fire regulation might require the preservation of existing stairways as fire escape.	• No external space available for use in retrofit • Acceptance of loss of dwelling space to accommodate new elevator installation	• No external space for use in retrofit • No internal space available for addition of elevator
DESIGN MEASURE OPTIONS	Addition of custom-sized elevator Replacement of half-landing to straight stairs	New vertical circulation core on side Addition of galleries	Addition of custom sized elevator Remodelling of existing staircase	New entrance
	New entrance	Reorganisation of dwelling access Reuse of old circulation space	Reorganisation of dwelling access New entrance	
TOP-UP CONSEQUENCES	Access to new-dwellings via central core per block. Gallery access is possible but allocates an 'unjust' amount of space to circulation.	Top-up dwellings access via a gallery or central corridor.	Same consequence as approach 1	Top-up can be still done but only to enlarge 4th storey dwellings into so called penthouses. Can provide added diversity compared to exiting condition

Table 5.5: Accessibility approach summary

STRUCTURE

The second discussed design aspect is structure, specifically whether a strategic intervention is necessary in order to accommodate a top-up. In the Suitable Typology analysis chapter the assumption was made that post 1950's concrete building with a flat roof had the necessary structural capacity to support a lightweight additional storey. This assumption was taken from previous densification studies, however, since taking the design to the next level of development it is possible to tackle the assumption more critically using the case-study building. The exploration of this aspect will look at specific considerations that need to be made for the structure of the building in order to make top-up viable.

Having examined, the case-study building archived drawings it is evident that the foundations of this Portiekflat are at a limit in terms of their bearing capacity. Thus, a top-up addition will require a structural intervention which will be explored further in the approaches for this design aspect. However, for the purposes of this design exercise, the other scenario, in which the foundations do have sufficient load-bearing capacity, was taken into account.

Top-Up Load-case

The first point that was considered was the actual new load-case, firstly live-loads as dead-loads can be influence later on during the design stage, that was added going to be added. Considering the minimum of a one storey top-up, that equates to 1.5kN/m2 for the dwelling space and 0.6kN/m2 per roof space (the bare minimum load-case for a flat roof with occupational maintenance requirements), totally 2.1kN/m2 for one storey addition.

Approach 1

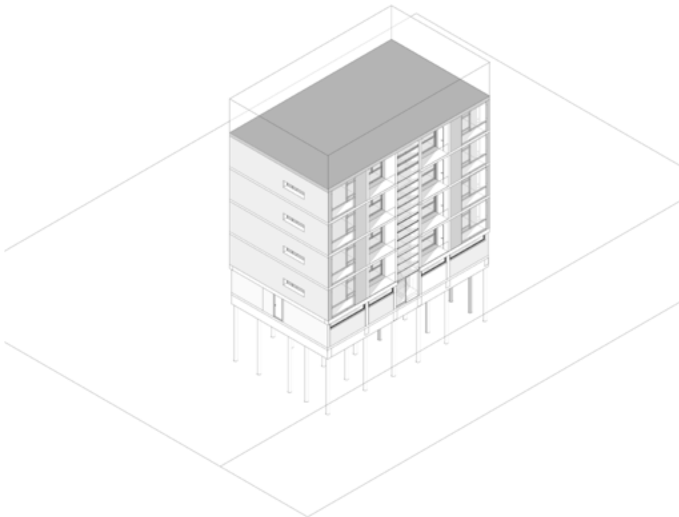


Figure 5.20 Isometric view of approach 1

The first approach follows the assumption made in the Suitable Typology analysis, that the existing structure is capable of supporting the 2.1kN/m2 of live loads together with a lightweight top-up and thus would require no structural intervention to the existing building. The obvious requirement being that this load-case complies with the existing structural capacity including the crucial bearing capacity of the foundations. During the design development a thorough review of the existing drawings will be necessary to investigate this further, otherwise a structural survey of the building will probably be required or safety measures need to be implemented as was done in the Rotterdam top-up case-study.

Furthermore, from the case-studies research, the finding showed that the most optimal method of transferring the top-up load to the existing loads, was to adopt the existing grid, by doing so loads are distributed evenly and floors are keep light.

Approach 2

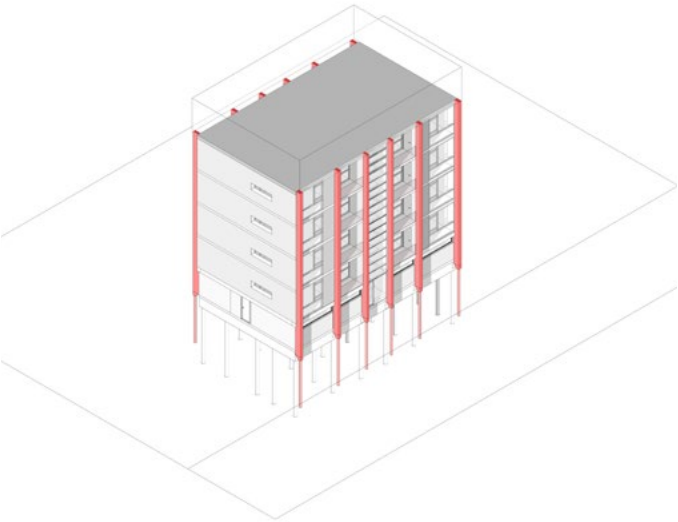


Figure 5.21: Isometric view of approach 2

The second approach explored, more in line with the predicament of the case-study building, employs the addition of an external structure which carries the new loads to either a set of new foundations or strengthened piles on the perimeter of the building. This, similar to accessibility, requires external space to be able to incorporate the new column with its supporting footing. The new structure would run along the existing grid lines,

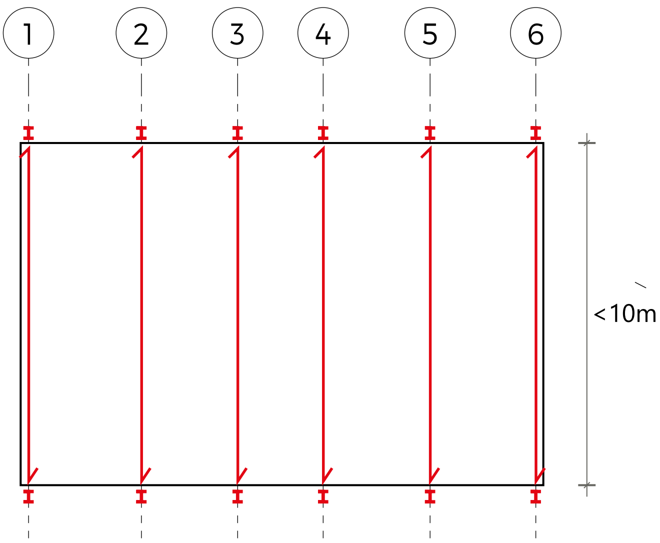


Figure 5.22: Roof plan showing spans for external structure

adopting the existing floor spans, see Figure 5.22.

Approach 3

The last approach explored looks at the only possibility left if the requirements for the other two approaches cannot be met, which is to strengthen the existing pile foundations. This approach is more of a specific measure rather than a strategic position.

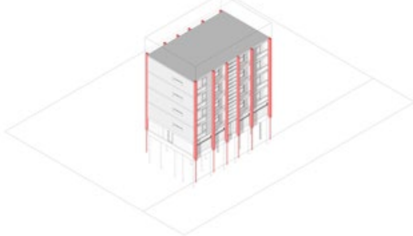
STRUCTURE SUMMARY	1. No structural intervention	2.External Structure	3.Foundation Strengthening
			
DESCRIPTION	No structural intervention necessary as existing structure has sufficient bearing capacity	An external structure, tied to the existing structure, brings loads down to new foundation.e.	Existing foundations to increase bearing capacity for Top-up load-case. Existing structural members are strong enough to transfer new loads to strengthen foundations.
CONDITIONS/REQUIREMENTS	• Determined load-case complies with existing structural capacity- no further structural intervention on existing state required. • New spans from Top-Up should comply with existing spans in order to effectively transfer loads to foundations.	• External space on long side to accommodate extra structure and new foundations (min 1m). • Concrete structural members in good condition, in order to accommodate bolting of new structure.	• Access to foundations with special equipment
DESIGN MEASURE OPTIONS	Renewal of existing roof to transfer new loads adequately to existing structure	New external structural columns tied to existing structural members New foundation New structure and corresponding loads transferred to existing foundations	Pile renovation
TOP-UP CONSEQUENCES	The load-case is constrained to the extra load-bearing capacity of structural columns. A maximum of one storey might only be possible	An new structure allows a reconsideration of load-case, meaning more than one storey might be possible if in the interest of project	Same consequence as approach 1

Table 5.6: Structure approach summary

HOUSING QUALITY

The housing quality is really the spatial arrangement and qualities that the residents are exposed to when living there. Given the age of these building and the period in which they were constructed, they do fall short on some qualities we would today take for granted. Therefore, it was added as a design aspect as it was found to have an overarching impact on the overall retrofit design strategy. It was specifically during design development of these approaches it was determined that this aspect was intrinsically linked with the overall top-up design, especially when considering improvements to accessibility. For this reason it was included as a design aspect for the retrofit design.

The improvements explored try to single out specific qualities that could be possibly added to the existing building, which could be used together with the other approaches in order to make the retrofit design strategy more viable as an integrated approach for various existing constraints the building typology has.

Improvement 1

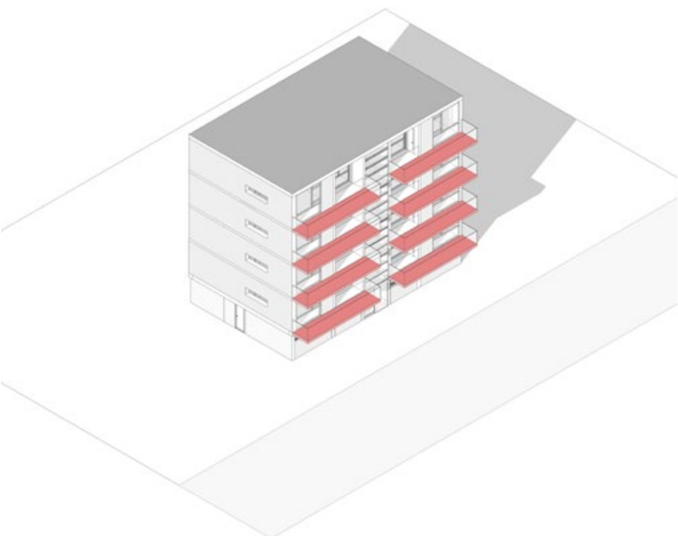


Figure 5.23: Isometric view of improvement 1

The addition of more external space, through the addition of balconies on the building envelope is one way to improve the quality offered by the dwellings, even though the existing dwelling already has a balcony space, albeit a very small amount area of roughly 3m2. A larger balcony space, extruding from the envelope, would encourage more use of the balcony, provide more shading and possibly compensate if the existing balcony is made into internal space as part of the energy performance improvements, as the current balcony exhibits a substantial thermal bridge.

The balconies can be bolted into the existing concrete frame with sufficient structural consideration. In terms of the energy performance, thermal breaks at the connection can be used depending on the overall energy performance approach. Their compatibility and feasibility also depends further on what approach is chosen from the other two design aspects, as the use of an external structure could simplify the implementation but a transition to a gallery-access would further restrict if not eliminate the option for this improvement at an early design decision stage.

Figure 5.24: Floor plan for improvement 1

Improvement 2

If external space can be added by addition of balconies then it could also be possible to increase the internal area of the dwellings by offsetting the thermal area of the building, offering the possibility of either a completely new envelope or a thermal buffer area that provides an added thermal protection to the retrofitted envelope.

The depth of expansion will depend on the structural limitations of either having to cantilever outwards from the existing structure or providing a support structure which would invariably permit a greater degree of flexibility to the expansion. Along with such an improvement it would be important to open the existing façade, implying a removal of some of the wall elements, to maximize the opening up of the internal space, shown in Figure 5.26.

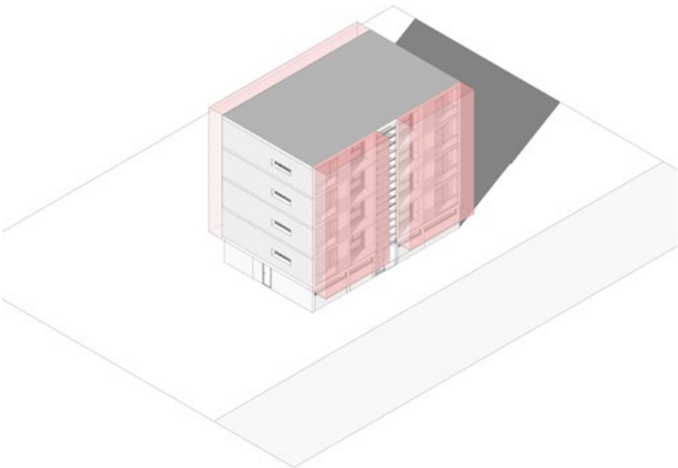


Figure 5.25: Isometric view of improvement 2

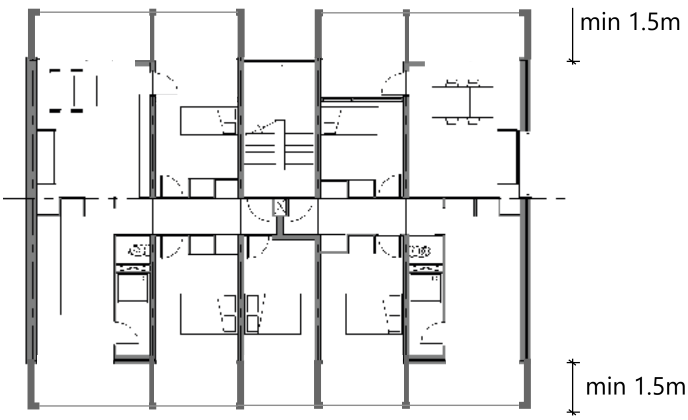


Figure 5.26: Floor plan for improvement 2

Improvement 3

This improvement entails improving the internal spaces by opening up the loadbearing walls. The extent to which this can be done varies depending on the existing conditions. However, by providing even minimal openings it can increase the perspective of the room, especially for the communal areas, without significant structural weakening. Nevertheless, the opening can be maximized with the use of a supporting structure and leaving certain depth above the opening to act beam supporting the above floor. However, complete openness has been found to require a lot of intervention, were demolition of the wall,

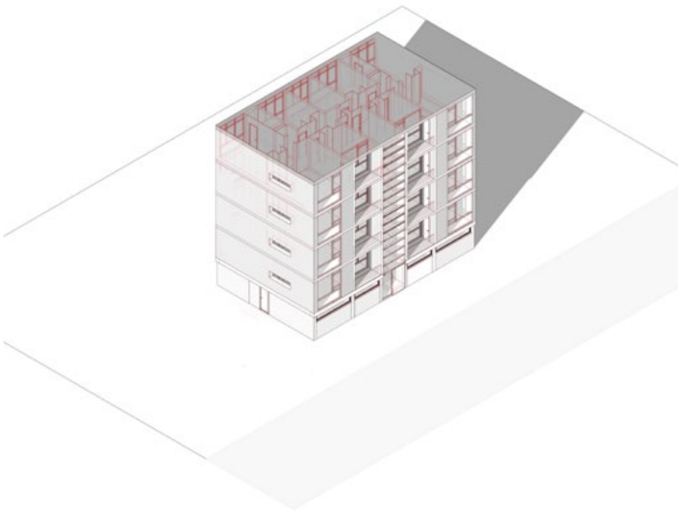


Figure 5.27: Isometric view of improvement 3

removal of floor and addition of temporary structure are required in Portiekflats. Removal of part of the wall, leaving a minimum of 60cm of overhead concrete wall and adding a ridge frame in the new opening, can provide a better option in terms of intervention level, time and cost (Verhoef, Hendriks, van Nunen , & Laurs, 2007). This recommendation was taken into account for this housing improvement and can be seen in Figure 5.28. It shows one, how the opening of only one loadbearing wall and creating a bigger communal space can already drastically improve the dwelling compared to the other dwelling. Using this level of intervention can provide the necessary means

Figure 5.28: Floor plan for improvement 3

to modernizing the dwelling. Of course, maximizing the openings together with additions on the façade, like for example balconies, might not be structurally feasible but requires further investigation.

Toolbox summaries

Tables 5.5, 5.6 and 5.8 provide the summaries of the different approaches for each design aspect explored with further measures that can be used along with the approach shown as Design Options. The next part will explore the decisions that might lead to selecting one approach over the other. These toolboxes combined with tables 5.2 and 5.3 that show the retrofit measures required to achieve a specific EPC target provide the necessary content for the Retrofit Toolbox of this thesis.

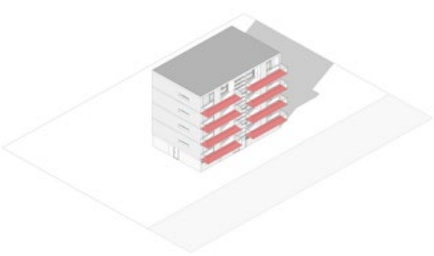
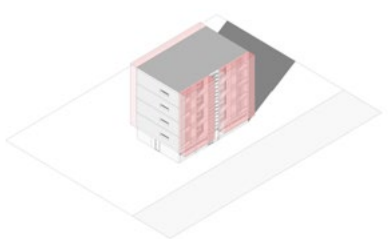
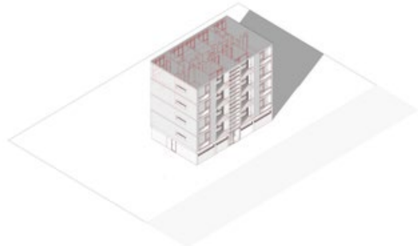
HOUSING QUALITY SUMMARY						
	1. Addition of balconies		2. Dwelling expansion		3.Internal Restructuring	
						
DESCRIPTION	Addition of balcony on either side of long facade. Can vary in size depending on required space		Increasing the internal space of the existing dwellings by extruding outwards on either or both long sides of the Portiekflat.		Restructuring of internal spaces by providing openings in the existing load-bearing walls to improve spatial qualities.	
CONDITIONS/REQUIREMENTS	• Available external space on long facade side • Concrete floor slabs and walls in good condition to bolt on additional structure. • Enough bearing capacity of existing structure or available external space for new external structure to bring loads to new foundations		• Available external space on long facade side • Concrete floor slabs and walls in good condition to bolt on additional structure. • Enough bearing capacity of existing structure or available external space for new external structure to bring loads to new foundations		• Careful consideration of potential weakening of structure resulting from opening up spaces	
DESIGN MEASURE OPTIONS	Bolt on balconies to existing floor slabs	Use a new structure tied to existing structure member to support balconies	Bolt on new structure to existing structural member	New foundations	Openings in load bearing walls	Structural framing for openings
	New foundations		Use a new structure tied to existing structural members to support new spaces	New entrance	Internal reorganization of dwelling spaces	
TOP-UP CONSEQUENCES	The load-case is constrained to the extra load-bearing capacity of structural columns. A maximum of one storey might only be possible		An new structure allows a reconsideration of load-case, meaning more than one storey might be possible if in the interest of project		Due to potential weakening of load-bearing capacity, top-up loads might need no supporting structure to compensate, see Strutural Toolbox	

Table 5.7: Housing quality improvement summary

DESIGN-DECISION TOOL APPROACH

Having outlined the individual approaches for each design aspect it was important to provide a tool that allowed, in this case, a social housing cooperation, to quickly pick the approaches necessary for a coherent design strategy for their building stock of Portiekflats. The tool, framed in a manner that prioritizes energy retrofitting first and then provides further considerations towards top-up, should leads the user to a design strategy brief, see Figure 5.29, which should offer integrated solutions based on the decisions they made regarding the approach for each design aspect. The utility of such a tool rests in the quick choice that can be made for each approach as the main design-decisions and logic behind them are packaged and provide a pathway to each approach which the user can follow when considering retrofitting a 1950's Portiekflat. Moreover, it can be used for creating a roadmap for retrofitting and densifying the existing building stock of this particular typology.

On the following page you can find the final version of the design-decision diagram; Figure 5.30 illustrates the structure behind the decision tool. It prioritize the different design aspects and their equivalent approaches that guide the user using some key questions and considerations to the different suitable approaches for a Portiekflat they wish to retrofit. The question are representative of some that had to be asked and answered during the design development of the approaches, but are simplified for the purposes of satisfying a degree of user-friendliness. The combinations of the set of retrofit measures with the different design aspect approaches for structure accessibility and thirdly, housing quality, generates the design strategy for the retrofit design.

Once the design strategy is set, further explorations of more specific design aspects that encompass more technical measures can be explored for the case-study of this thesis.

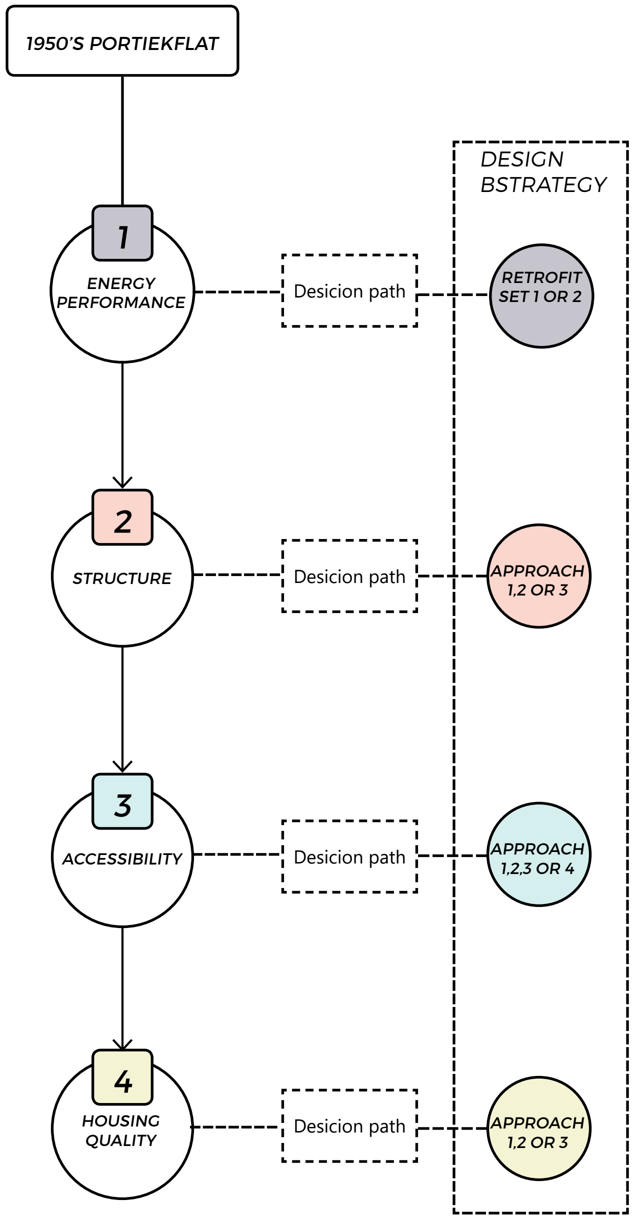


Figure 5.29: Design strategy diagram

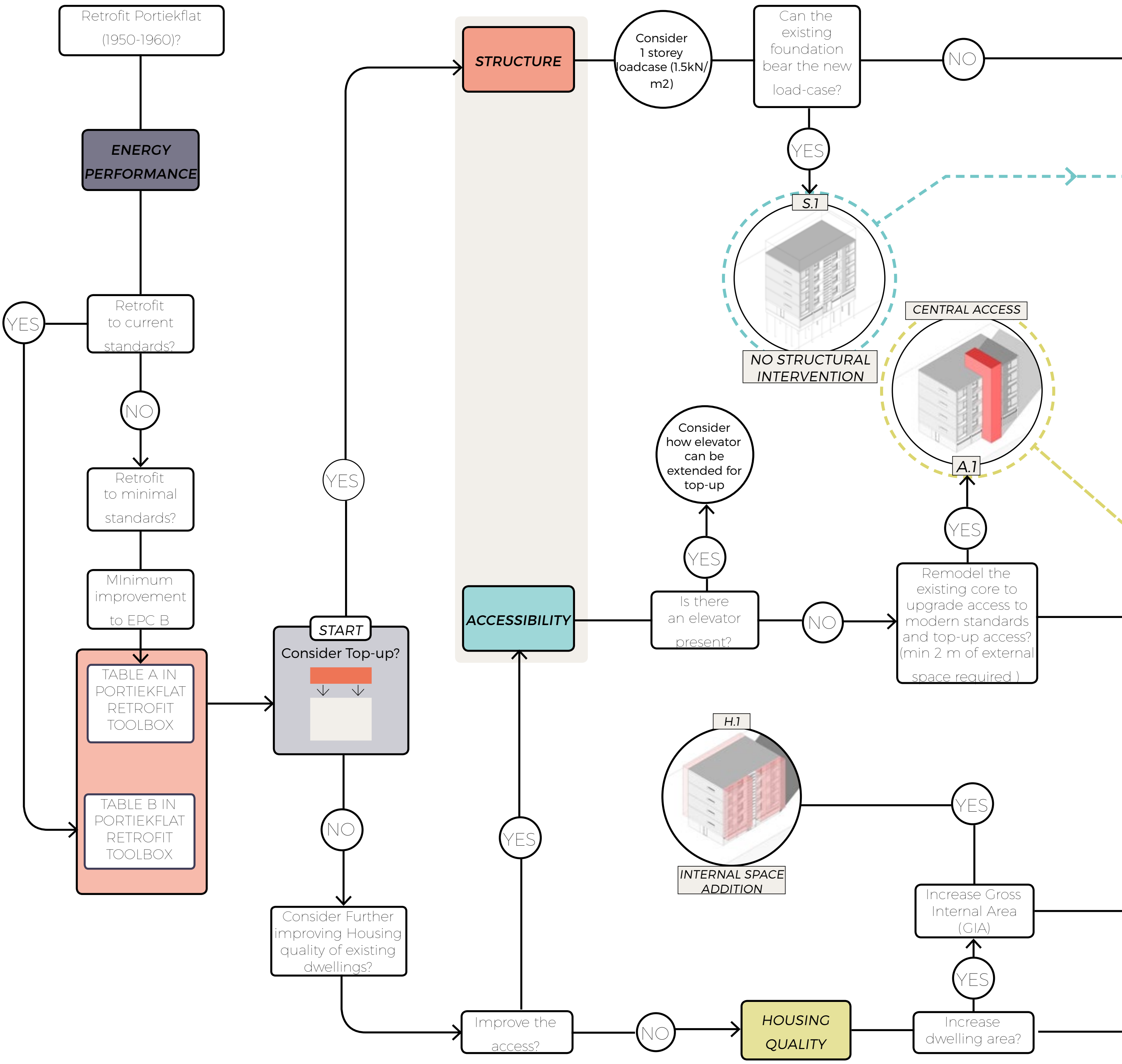
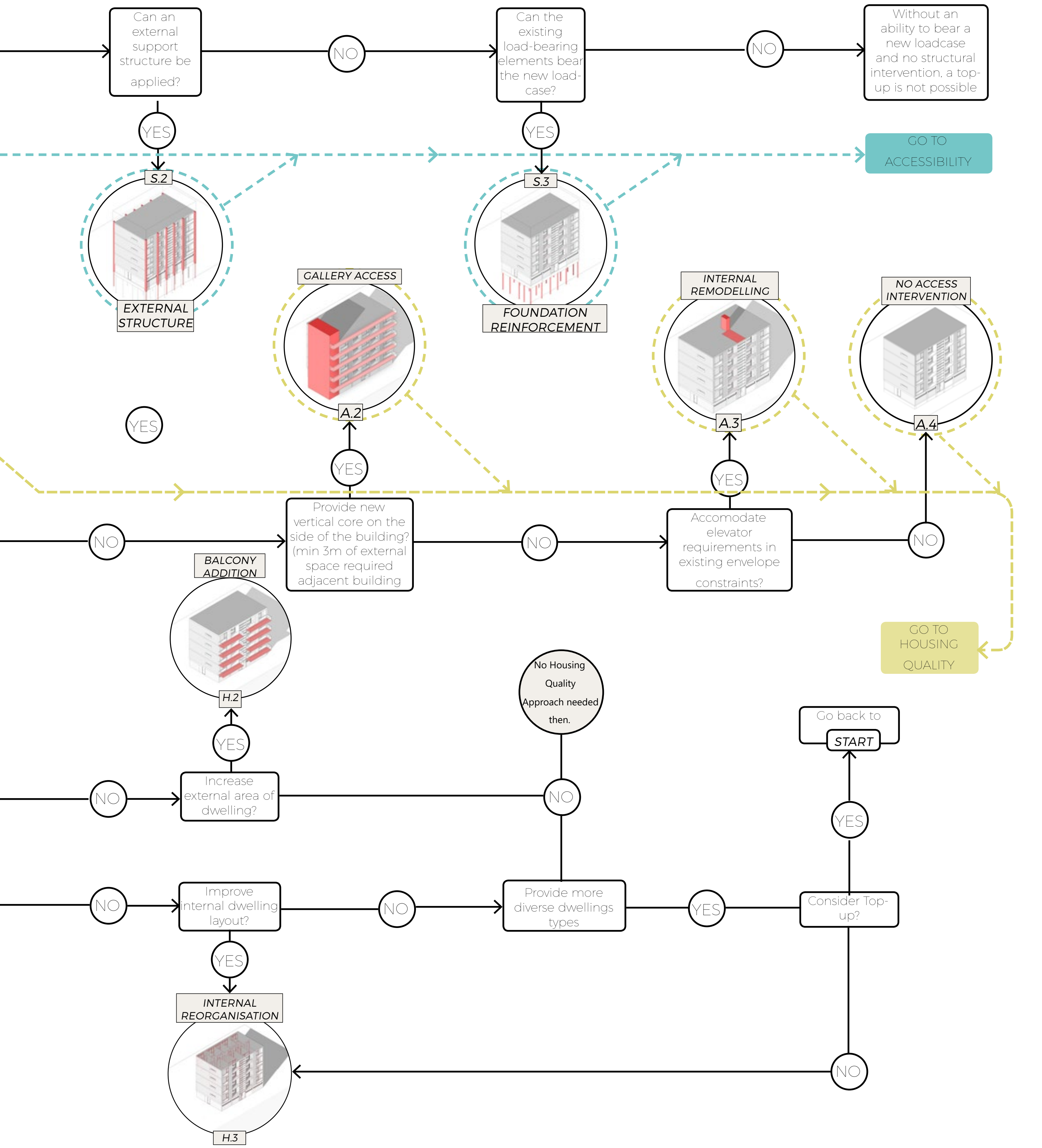


Figure 5.30: Decision-making Tool for social housing corporations



Can an external support structure be applied?
NO
Can the existing load-bearing elements bear the new load-case?
NO
Without an ability to bear a new loadcase and no structural intervention, a top-up is not possible
YES
YES
GO TO ACCESSIBILITY
S.2
S.3
EXTERNAL STRUCTURE
FOUNDATION REINFORCEMENT
GALLERY ACCESS
INTERNAL REMODELLING
NO ACCESS INTERVENTION
YES
A.2
A.3
A.4
YES
YES
NO
Provide new vertical core on the side of the building? (min 3m of external space required adjacent building
NO
Accomodate elevator requirements in existing envelope constraints?
NO
BALCONY ADDITION
GO TO HOUSING QUALITY
H.2
No Housing Quality Approach needed then.
Go back to START
YES
NO
Increase external area of dwelling?
NO
YES
NO
Improve internal dwelling layout?
NO
Provide more diverse dwellings types
YES
Consider Top-up?
YES
INTERNAL REORGANISATION
NO
H.3

COMBINING APPROACHES

Combining the different approaches given each decision path, established during the design development of these approaches, creates a design strategy to form the basis of the retrofit design. The next part demonstrates how these approaches for structure and accessibility can be combined and whether these combinations lead to opportunities for improvements in housing quality or addition or re-placement of a retrofit measure, all of which are summarized in Table 5.8 in the following pages.

The design methodology produced a total of 8 distinct design strategies between structure and accessibility; these are explored further in the following pages. An early discovery in the relationship between structure and accessibility approaches was that the 3rd approach for structure, namely the reinforcement to of the foundations, can be considered within the same design strategy as the combinations with approach 1, no structural intervention. These 8 combinations are further developed with considerations into house housing quality improvements and how each improvement might be relatively more viable given the design strategy. Presented in the following pages is the final design strategy brief, Tables 5.9 and 5.10, that illustrate the approach combination between the top-up design aspects with further consideration for housing improvements 3.A and 3.B. Housing improvement 3.C has been omitted from the design strategy brief because its integration within the retrofit design works for the most part independently of the other selected approaches.

COMBINATION TABLE FOR SECLECTED APPROACHES

TOP-UP ASPECTS			
STRUCTURE	*ACCESIBILITY*	*HOUSING QUALITY*	*DESIGN STRATEGY*
1.A	2.A	3.A	1
		3.B	
		3.C	
	2.B	3.A	2
		3.B	
		3.C	
	2.C	3.A	3
		3.B	
		3.C	
	2.D	3.A	4
		3.B	
		3.C	
1.B	2.A	3.A	5
		3.B	
		3.C	
	2.B	3.A	6
		3.B	
		3.C	
	2.C	3.A	7
		3.B	
		3.C	
	2.D	3.A	8
		3.B	
		3.C	
1.C	2.A	3.A	1
		3.B	
		3.C	
	2.B	3.A	2
		3.B	
		3.C	
	2.C	3.A	3
		3.B	
		3.C	
	2.	3.A	4
		3.B	
		3.C	

Table 5.8: Design strategy combinations

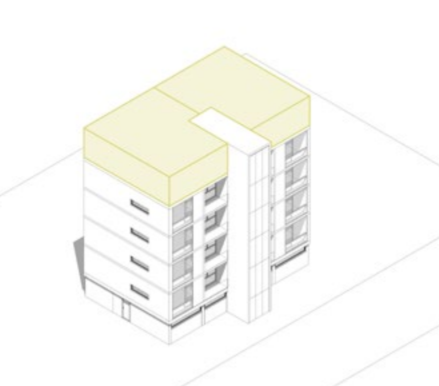
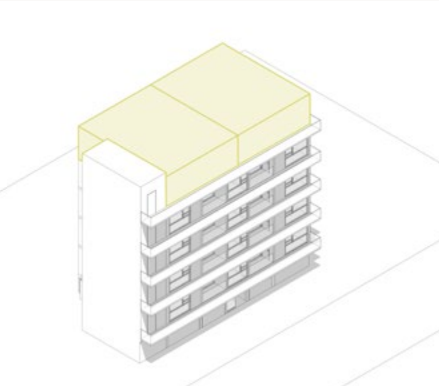
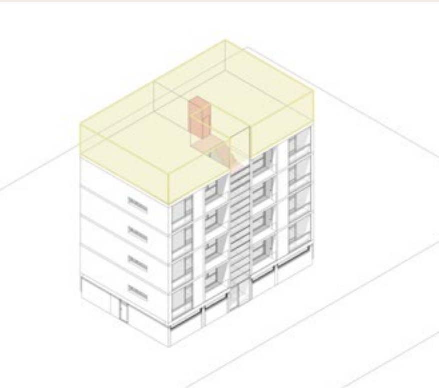
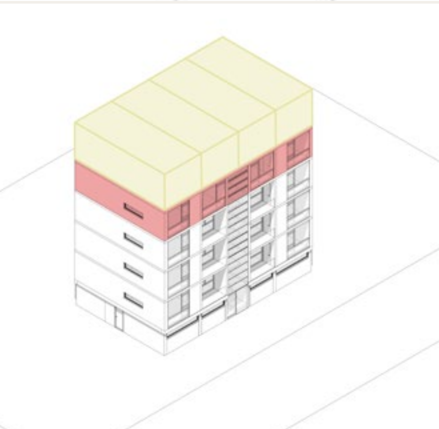
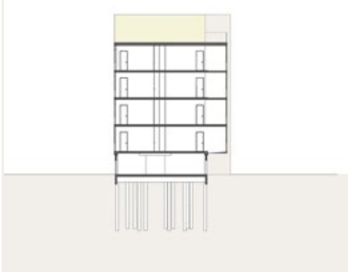
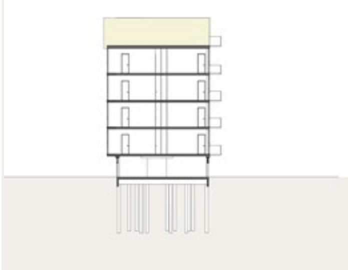
		DESCRIPTION	RETROFIT MEASURE OPPORTUNITY
1.		Central core remodelled (2.A) with or without foundational reinforcement (1.A or C), resulting in the extrusion of the entrance space. Remodelled core can provide extra structural stability for Top-up structure and/or any housing improvements done. Favavorable to include 3.A and 3.B on the entrance side so as to use.	• Roof measure can excluded as thermal envelope continues.
2.		Top-up supported by existing structure (1.A) with circulation altered to gallery-style access (2.B), with new circulation core errected on the short-end of block. . Top-up dwellings can be accessed either via gallery or central corridor Housing improvements such as 3.A and B can only be done on opposite side of galleries. Improvement 3.C is required to reuse previous circulation space.	• Roof measure can excluded as thermal envelope continues. • Galleries can be used as thermal buffer space.
3.		Circulaiton core is remodelled without using external space, resulting in new central elevator and half-landing staircase to access both existing and new dwellings. Similar to Design Strategy 3, housing improvements 3.A and B will only be viable on one side due to external space restrictions. =	• Roof measure can excluded as thermal envelope continues.
4.		In case of no access alterations (2.D), a Top-up can only serve to increase dwelling size of top-storey apartments. This scenario does not lead to densification in the sense of adding more dwelling-capacity. But it does diversify the dwelling-types offered by building typology.	• Roof measure can excluded as thermal envelope continues. • Existing roof requires complete remodelling.

Table 5.9: Design strategies 1-4

3.A		*3.B*	
	• Thermal buffer creation possibility on one or both sides of long facades • Shading consideration with balconies		• Measure for external wall needs to be revised.
			
			

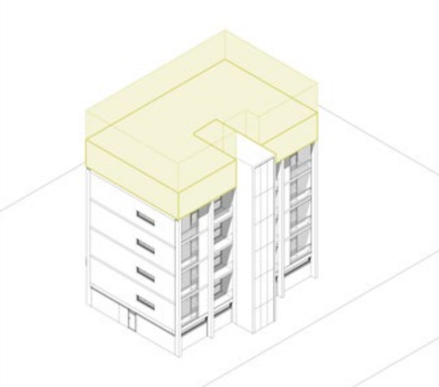
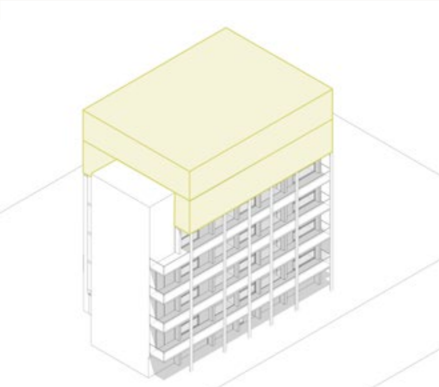
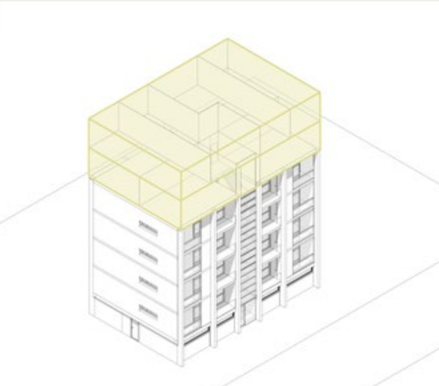
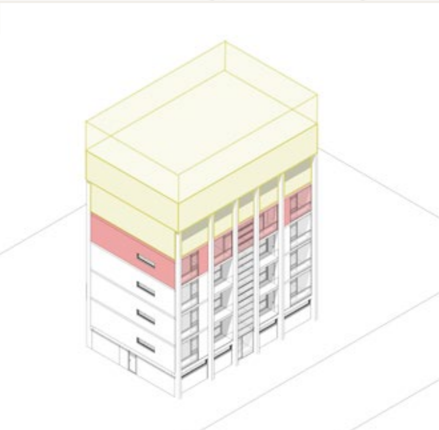
		DESCRIPTION	*RETROFIT MEASURE OPPORTUNITY*
5.		Central core remodelled (2.A) with external structure (1.A), which provides added capacity to include two stories minimum. The external structure makes it much more viable for housing improvements as structural requirements can be offset to new structure.	• Roof measure can excluded as thermal envelope continues. • Shading device can be installed on external structure
6.		Circulation changed to gallery access (2.B) with external structure added to support Top-up (1.B). The external structure makes it much more viable for housing improvements as structural requirements can be offset to new structure, including new galleries	• Roof measure can excluded as thermal envelope continues. • Shading device can be installed on external structure
7.		Circulation managed within existing envelope (2.C) with external structural addition (1.B). The external structure makes housing improvements more viable, external space might be restricted and probably only one side will be available for improvement.	• Roof measure can excluded as thermal envelope continues. • Shading device can be installed on external structure
8.		No access intervention (2.D) with addition of external structure (1.B). The external structure can allow greater increase of top-floor apartment providing 'super' penthouses. As this option is only used incase of complete external space restrictions, hosuing improvements 3.A and B are unlikely (maybe top apartments). Internal reorganisation is very necessary for top apartments (3.C).	• Roof measure can excluded as thermal envelope continues. Existing roof requires complete remodelling. • Shading device can be installed on external structure

Table 5.9: Design strategies 5-8

3.A

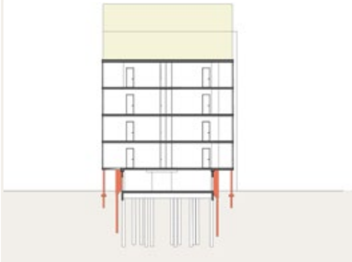
RETROFIT MEASURE

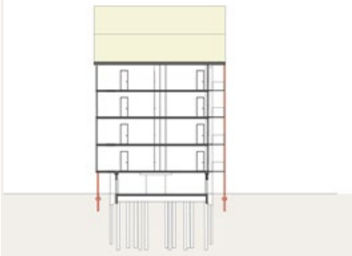
- Thermal buffer creation possibility on one or both sides of long façades
- Shading consideration with balconies

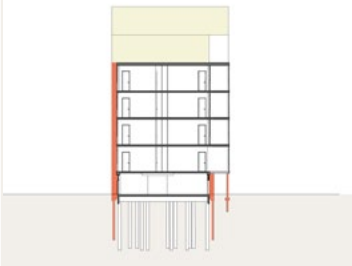
3.B

RETROFIT MEASURE

- Measure for external wall needs to be revised.







DESIGN STRATEGY BRIEF CONCLUSION

Having compiled the various combinations for specific the approaches for structure, accessibility and housing quality, as well as the set of retrofit measures, it offers the culmination of design strategies available to social housing corporations given design-decisions they would have to make for the stock of 1950's Portiekflats they need to retrofit. The decision tool demonstrates the design aspect priorities based on the findings of the literature study that would need to be addressed early in the design stage.

At the essence of the intervention each approach offers, is a way or method to overcome an existing constraints a portiekflat might exhibit due either typical properties or its immediate site conditions in an isolated manner. The design strategy considers foremost solutions to improving the energy performance aspect, which entails the measures required to achieve two different standards, one minimal and one more extensive, seconded by structural solutions, a decisive aspect in determining the practicality and success of a top-up; closely followed with accessibility and its possible interventions. Lastly, housing quality allows the stakeholder to explore whether improvements to the existing dwellings are viable given the rest of the design aspect.

The results of the design strategy brief show that there is a range of different integrations between the specific approaches, whose decision to use depends on the constraints. Integration of these approaches is judged by how they may compliment and work with one another. The only real isolated aspect that doesn't have much of an influence on the other approaches, is the energy performance aspect, that has been summarized with a set of measures for a given target. Regardless of the approach chosen for accommodating the top-up, the retrofit measures need for the most part a small alteration. The only big change regarding the other approaches, is the retrofit measure for the roof, which most sensibly is bypassed with the new top-up envelope than can continue the thermal-layer from the retrofitting façade. However, some opportunities to compliment the retrofit measures can be found. For example, if galleries, as part of the accessibility approach chosen, or balconies, as part of housing quality improvement, the question whether it can benefit the retrofit strategy needs to be addressed. For the most part, glazing these elements to create a thermal buffer space will help improve the energy performance of the thermal envelope or the shading provided can help avoid overheating during summer months. The greatest amount of integration can occur when the use of an external structure is used, as it is able to eliminate the constraints imposed by the structural bearing capacity of the building, together with sufficient external space which the retrofit design utilize. If these approach and condition align then the most sensible access approach can be utilized and all housing quality improvements are unrestricted and can be maximized in the retrofit design.

Moreover, having identified the specific decisions that need to be made and in what order, it is possible to use the results of this tool to contribute to a possible roadmap the housing corporation might want to make, in order to assist with the planned grand renovation of its building stock, which Staatgenoot has already signalled to do (Anderlesen, 2016), with opportunities they might not have considered with the tool. A roadmap refers to a time-lined strategy that indicates when, where and what needs to be intervened upon given a vision or a goal. The tools offered could facilitate in identifying which specific Portiekflats are most viable and require the least intervention, as the housing corporation, due to their financial constraints, will want to target the part of their stock that achieves the specified target, in terms of energy-savings and densification, requiring the least amount of intervention for all design aspects. As the results identify key constraints that are necessary for an intervention, the building stock could be analysed according to these constraints to categorize the stock on a spectrum ranging from least degree of intervention to the most advanced interventions and match appropriate design strategy to them. The key questions that would need to be answered from the building stock owned by the stakeholder are:

1. Which Portiekflats will be retrofitted?
2. What buildings have foundations with structural bearing capacity?
3. Which buildings have the spatial requirements for accessibility approach 1?

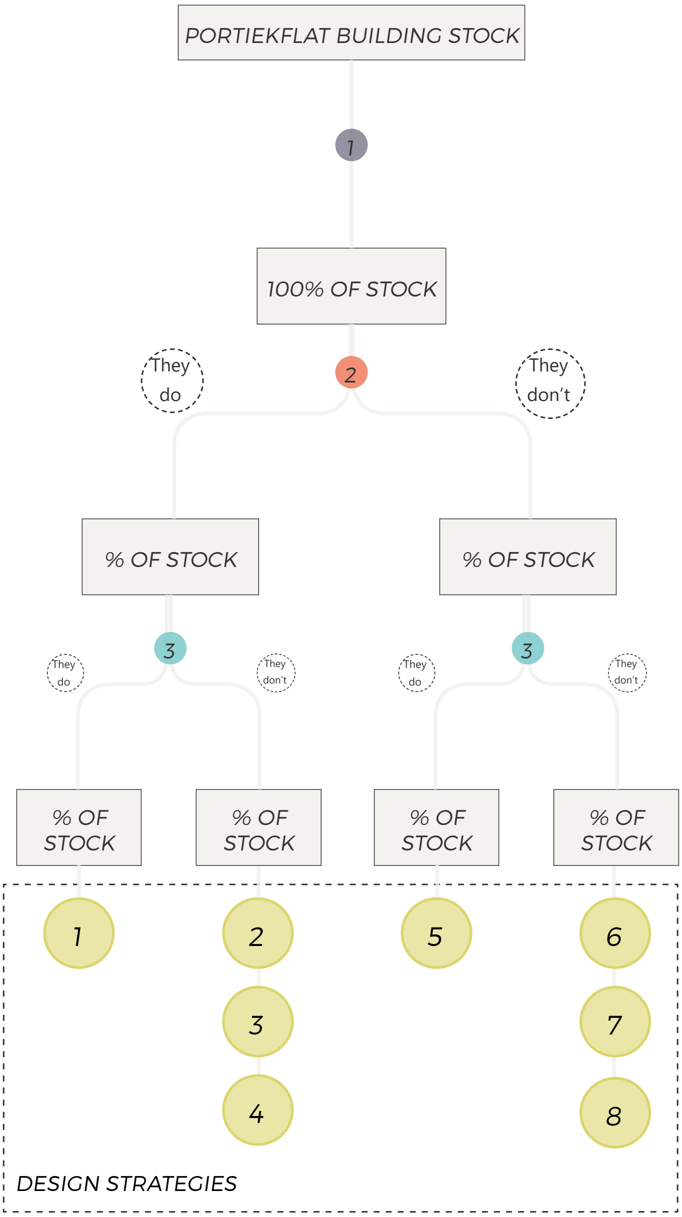


Figure 5.31: Selection diagram based on roadmap questions to pair portiekflats with design strategy.

Using these questions, the building stock can be sorted out in appropriate groups that will end up corresponding with a design strategy that is suitable for that group as presented in Figure 5.31. By allocating each building with a design strategy it could present the base research for the creation of a roadmap which enables social housing corporations to effectively address the retrofitting of their 1950's Portiekflat stock.

BOUWEN ERWOUTSZSTRAAT DESIGN STRATEGY

The case study chosen on Bouwen Erwoutsztraat, helped to inform several of the typological properties and characteristics of Portiekflats, which produced the generic model to explore different approaches. However, continuing the design process to a more technical level, it required focusing on the retrofit design for the this specific case using one of the design strategies described in the previous section and exploring it further by considering the other design aspects such as the building services, construction and architectural quality of the top-up dwellings.

Before this design stage, picking the design strategy using the same decision logic had to be demonstrated, shown in Figure 5.32. Choosing the energy performance aspect of the design, either the minimal or the more elaborate application of retrofit measures to achieve current standards, the latter was chosen, in the interest of this thesis. However, the consequent aspects for the top-up approaches were chosen taking into account the constraints and opportunities provided by the case-study building. In terms of Structure, approach 2 was chosen, as the drawings indicated an explicit limitation in the bearing capacity of the foundations together with the fact that there is enough external space for an external structure to be applied. The decision behind the accessibility approach, approach 1, hinged on the fact that the entrance space has enough space for expanding into it, making it the easiest way to accommodate an elevator as spatial reorganization of existing dwelling to accommodate the latter approaches is regarded as a lot more interventionist. The last approach chosen for the design strategy in the name of housing quality was Approach 2, the addition of external space. This decision will usually depend on the clients, the social housing cooperation, who with restricted means might find this approach desirable for improving the housing quality of their existing dwellings, as they would be replacing the previously lost external space, the existing balcony is closed up to eliminate thermal bridges, with a more adequately dimensioned one. The balconies can also compliment some of the other approaches chosen; the addition of the external structure makes incorporating new balconies more feasible in terms of installation as they can be separated from the building envelope and in terms of the retrofit strategy, they can provide shading and can be easily be converted into a thermal buffer space by glazing them. In the next design phase, the other design aspects identified in the literature study can be explored, namely construction and building services, with the use of some key questions to guide the design forward:

1. What type of dwelling should the top-up provide?
2. Can the external structure provide sufficient support for more than one storey?
3. How can the top-up be constructed?

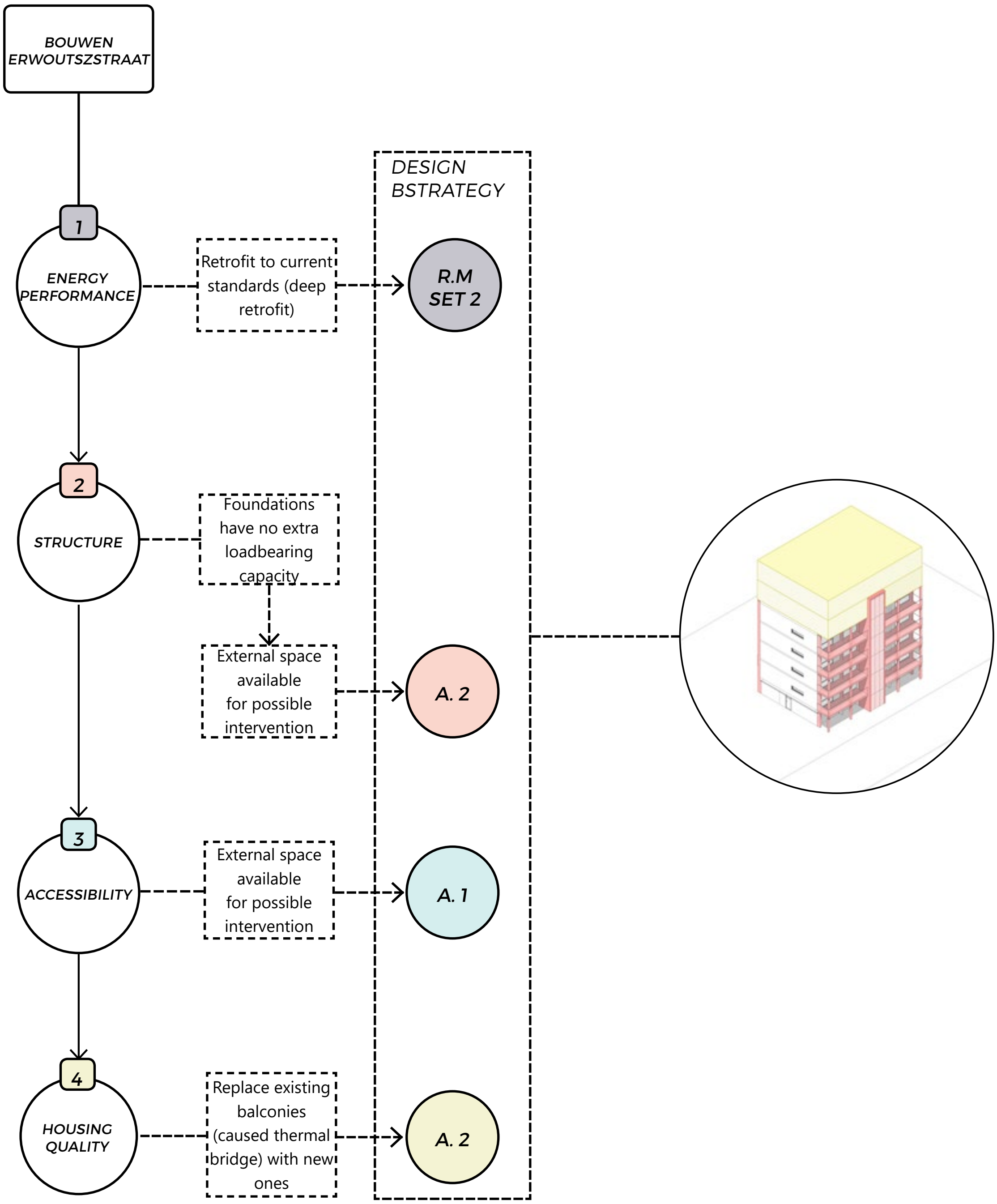


Figure 5.32: Diagram showing decision logic of design aspect aproach choice.

TOP-UP BRIEF

The brief for the top-up design has to provide the type of dwelling desired by the stakeholder. The main source for this decision was the 2016 business plan of Staatgenoot; inside the document it entails a lot of critical insights about the future ambitions and interests of the cooperation aligning them with the current urban developments, this is elaborated on in The Stakeholder section. In regards to dwellings, they express the desire to provide one to two person households in areas close to the city centre reflecting current demands for urban accommodation.

Furthermore, the retrofit design together with the design methodology already complies with many of their concerns about the future of their building stock; it provides options for energy reduction in line with their goals; it enables an accessibility upgrade, allowing all tenant demographics proper access of their stock; and the transition from a typology with a single dwelling type supply to a diverse dwelling type supply, all of which directly align itself with the renewal ambitions of the area and the stakeholder.

EXTERNAL STRUCTURE

The usage of an external structure to divert the top-up loads into new foundations brings into question whether it's possible to provide an additional storey to maximize the densification area as well take full advantage of such a structural intervention. As a starting point for the design strategy, it was assumed possible and a matter to resolve in the detailed level. Having identified the other approaches, this section aims to show how the structure was integrated with the other approaches on a detailed level but also highlight some limitations. The concept for the external structure is summarized in the diagrams shown in Figure 5.33. The idea being that a slender structure can be utilized using the stability of the of existing building and the remodelled core. The main calculation that was made for the structure was for the beam that spans the width of the building, this is explained in Appendix B.

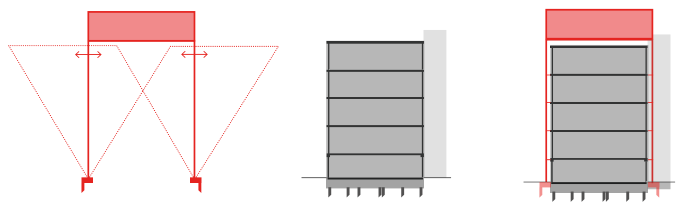


Figure 5.33: Structural concept of external structure

The main limitation are created by the restriction in expanding outwards in terms of remodelling of the existing core. As the stairs are changed from half-landing to straight there is a restricted amount steps that the flight can have before being interrupted by a landing, which as a general rule should not surpass 18 steps for residential dwellings. Depending on the height of the top-up level the number of steps may need to increase making the staircase take up more space which further pushes the extension outwards, see the section in Figure 5.34. The current case-study does have a restriction given the current layout of the road, it was determined that the core should not push further than 2.5m, so as not to take more than 50% of the existing pavement. Moreover, the driving factor for the height of the top-up level is the depth of the beam used to span between the long sides of the building. With the 18 steps restrictions, that only provided a margin of 600mm depth to accommodate the beam. This was resolved and the structural calculation are presented in Appendix B.

The structural calculations showed that a beam with a second moment of area of at least 77160cm4 was needed, which led to considering the different industry standard steel beams available. Table 5.10 summarizes the three profiles that were considered. Beam 3 was chosen in the end as that minimized the depth between the Top-up level and existing roof level the best. The disadvantage of this choice is that it is the heavier choice.

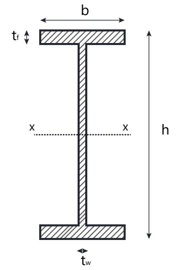
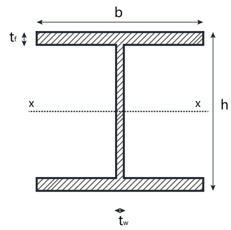
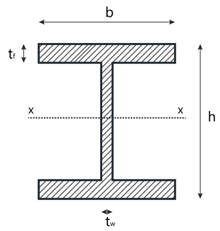
STEEL PROFILES	DIMENSIONS		WEIGHT	2ND MOMENT OF AREA (x-AXIS)
1. UB 457x191x161	(mm)		kg/m	cm^4
	b	199.4	161.4	79779
	h	492.0		
	tw	18.0		
	tf	32.0		
2. UC 356x406x235				
	b	394.8	235.1	79085
	h	381.0		
	tw	18.4		
	tf	30.2		
3. UC 305x305x283				
	b	322.2	289.9	78872
	h	365.3		
	tw	26.8		
	tf	44.1		

Table 5.10: Steel profiles specifications

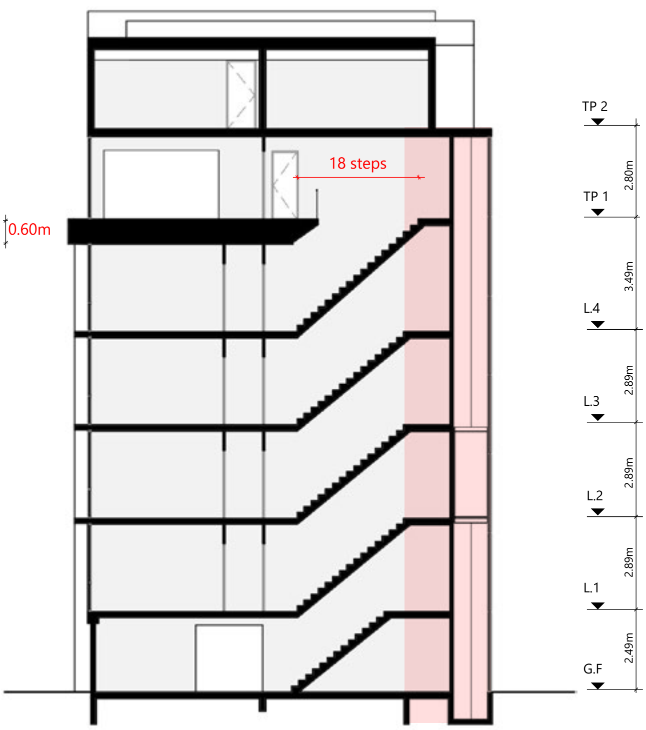


Figure 5.34: Building section through circulation core.

TOP-UP DWELLINGS DESIGN

Given the fact that a two storey intervention is possible, effectively doubling the densification potential of the case-study building the question about the type of dwellings to use this potential arose. As discussed earlier, Staatgenoot's desire to provide more one to two bedroom household was made explicit in the business plan of 2016. Whether this could be accommodated given the design approaches selected was a point of exploration. Two-bedroom flats tend to be less than 60 and 80m2, given the total area available across the two top-up levels totalling about 1300m2 it would suggest that about 20 new two-bedroom dwellings could be added.

The actually design steps that produced the final top-up dwelling type offered a different outcome with a total of 16 new dwellings. The following images presentin in Figure 5.35 encapsulate the design steps that were undertaken to produce the final outcome.

1. Area in contention: 766.5m2
2. Top-up area can be doubled to 1533m2 given external structure
3. With one floor access, to keep intervention at minimum, access point to 4 dwellings are created – volume is divided up into four to create 4 distinct volumes, offering possibility to create 2 different dwelling typologies that mirror one another.
4. Alternating pushing of the volume creates external balcony space which given the North to south orientation of the building, allows the different volumes to provide shading from eastern and western solar rays.
5. Finally roof is made to slope to create favourable conditions for solar panels. Southern slopes provide the most area and are sloped at a minimum of 20.

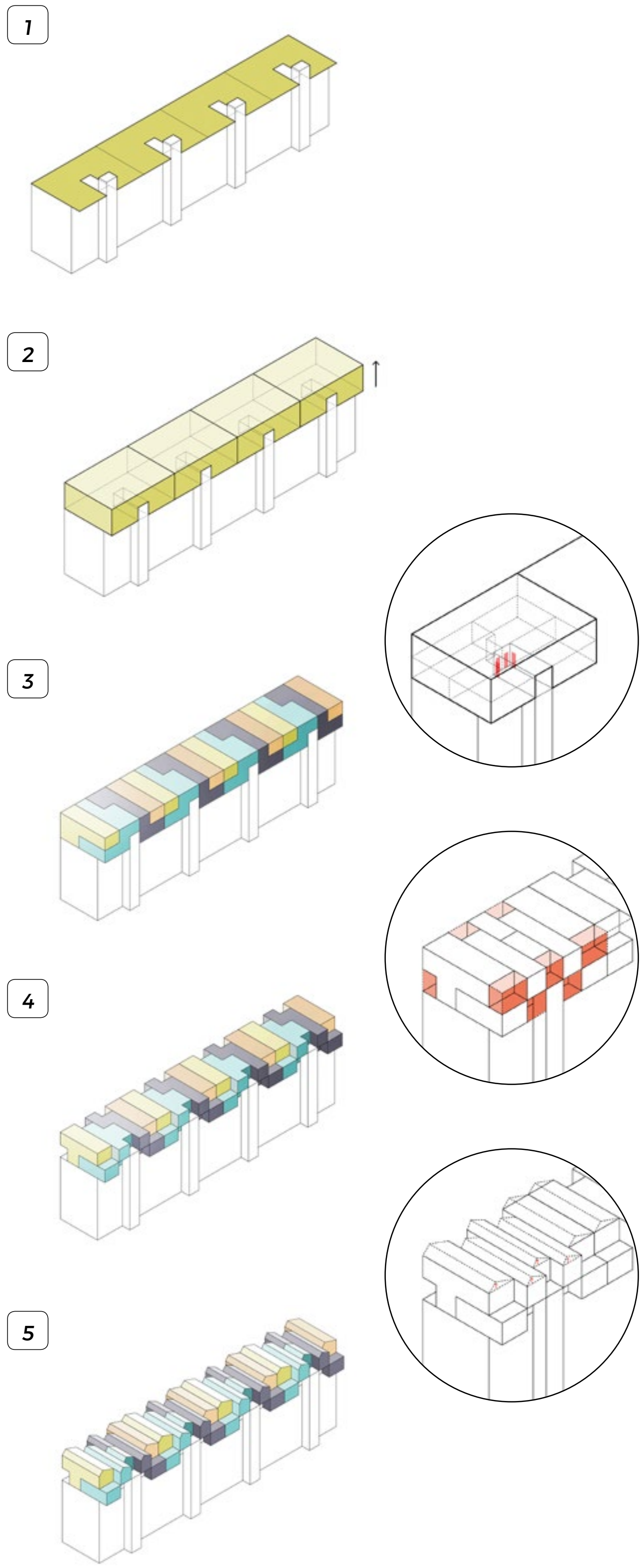


Figure 5.35: Design steps diagram

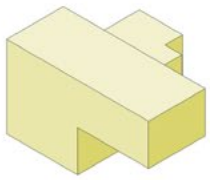
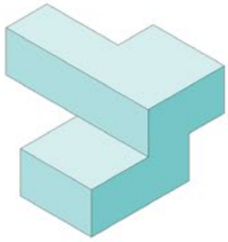
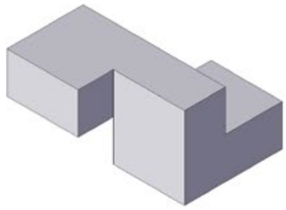
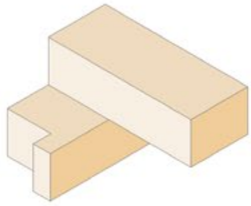
	TYPE 1			TYPE 2			TYPE 3			TYPE 4		
Dwelling Volumes												
PLAN	*1st Level* 						*2nd Level* 					
	1st Level	2nd Level	Total	1st Level	2nd Level	Total	1st Level	2nd Level	Total	1st Level	2nd Level	Total
GIA (M^2)	41.1	39.0	80.1	36.1	40.9	77.0	35.7	36.5	72.2	30.5	38.8	69.3

Table 5.11: Top-up dwelling typology

The volumetric division created an interesting type of dwelling the benefits from two distinct levels as well as external space. In the end, the design development of the dwelling plan rendered four distinct dwelling typologies of varying sizes and number of bedrooms that range between one and two. The dwelling typology and its specifications are presented in Table 5.11.

TOP-UP ENERGY PERFORMANCE

As the Top-up dwellings can be considered as new-builds, they need achieve current building standards in terms of thermal performance of its envelope. Therefore, the aim was achieving an EPC value of 0.4 for the Top-up portion of the retrofit. The design of the Top-up offered some opportunities to take advantage of passive and active measures. Firstly the creation of balconies from pushing the dwelling volume in an alternative manner, provides, by shape of the volume, lateral shading on the east and west faces of the façade. Secondly, the sloping of the roof also creates the necessary space underneath for the various building systems, see Figure 5.36, while providing optimal angles for solar panels, either PV or thermal. Lastly, the building envelope elements were configured to comply with current building standard, as summarized in Table 5.12, to achieve necessary thermal resistance.

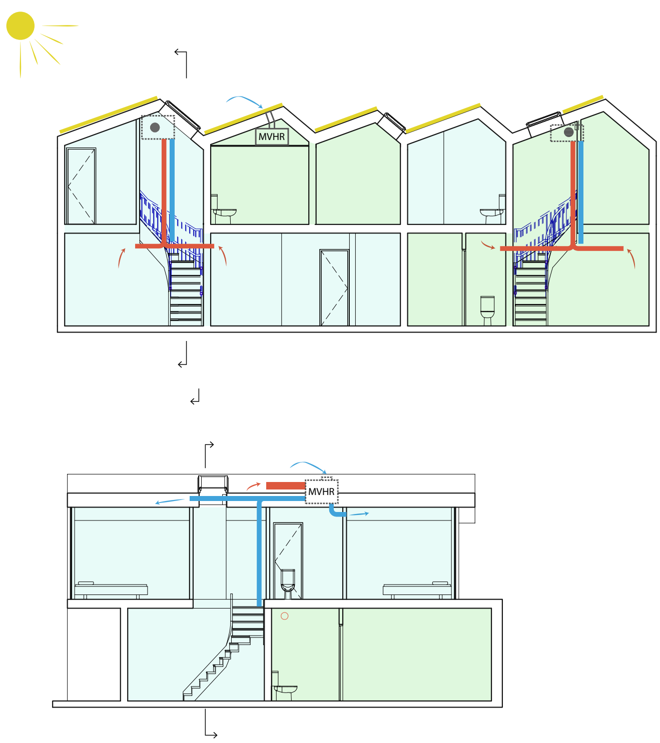


Figure 5.36: Top-up section shoiwng climate system

TOP-UP ENERGY PERFORMANCE

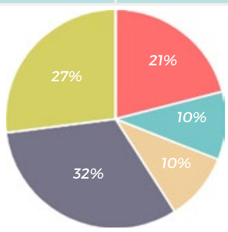
TOP-UP BUILDING ENVELOPE	*CONSTRUCTION*	*TARGET (W/m²K)*
1. External Wall	180mm Timber-box element (Lignatur) (rc = 2.53m²K/W) + 175mm expanded polysterene insulation (EPS) (4.8m²K/W)	0.17
	158mm CLT panel (1.21m²K/W) + 175mm expanded polysterene insulation (EPS) (4.8mm²K/W)	0.17
2. Window	Triple Glazed	0.80
3. Balcony	180mm Timber-box element (Lignatur) (rc = 2.53m²K/W)	0.23
4. Roof	145mm CLT panel (1.12m²K/W) + 180mm EPS insulation (4.9m²K/W)	0.17
	125mm CLT panel (0.96m²K/W) + 180mm EPS insulation (4.9m²K/W)	
5. First Floor Top-up	Where needed:160mm Timber box element (2.21m²K/W) + 80mm EPS insulation (2.16m²K/W)	0.13
BUILDING SERVICES		
Space Heating	Hybrid heat pump (Air) + solar	
Domestic Hot Water	Hybrid heat pump (Air) + solar	
Ventilation	MVHR (85% efficiency)	
ENERGY PERFORMANCE	*21.6kW/m²/a* *EPC A++ (0.31)*	*66% share of renewable energy*
lighting *fans* *space heating* *DHW* *summer comfort*		

Table 5.12: Top-up Uniec Results

Retrofit measures

For the most part the retrofit measures illustrated in Table 5.3 to achieve an EPC of 0.4 are unchanged for the existing building. However, as the design strategy illustrated, new balconies can be added and is in the interest of the stakeholder, as the set of retrofit measures developed to achieve high energy performance means incorporating the existing balcony into the thermal envelope as it presented a significant thermal bridge in the construction. The new balconies can be incorporated with the external structure so as not to present a thermal bridge, and with the addition of glazing, can be converted into a thermal buffer to further benefit the energy performance of the building. As it's on a west orientation the thermal buffer space benefits from afternoon sun and pre-heated air can be used by the air-heat pump. The other measure that is excluded for the design is for the roof, as the envelope continues to the top-up, minimizing the intervention of the retrofit measure. The added measures are illustrated in Figure 5.37.

EPC Final calculation

A final Uniec calculation was run for the whole building, the main results shown in Figure 5.34, which shows that a final 85% energy reduction compared to the existing conditions. Even though, an EPC score of less 0.4 to comply to with current energy standard in the Netherlands, the total energy reduction is significant enough to make it a successful retrofit that also increases the dwelling capacity by a further 50% (16 new dwelling added to the existing 32 dwelling block).

It is important to note that this energy-reduction calculation method is a simple estimate of the potential effect the measures. The methodology relies on a prescriptive method to estimate the EPC value as dictated in the Dutch regulations. Therefore, measures like the addition of a thermal buffer were not possible to be inputted into the calculation software. This would require a more in-depth energy-performance simulation which this thesis does not provide due to time limitations. Furthermore, all the Uniec 2 summary calculations can be found in Appendex C

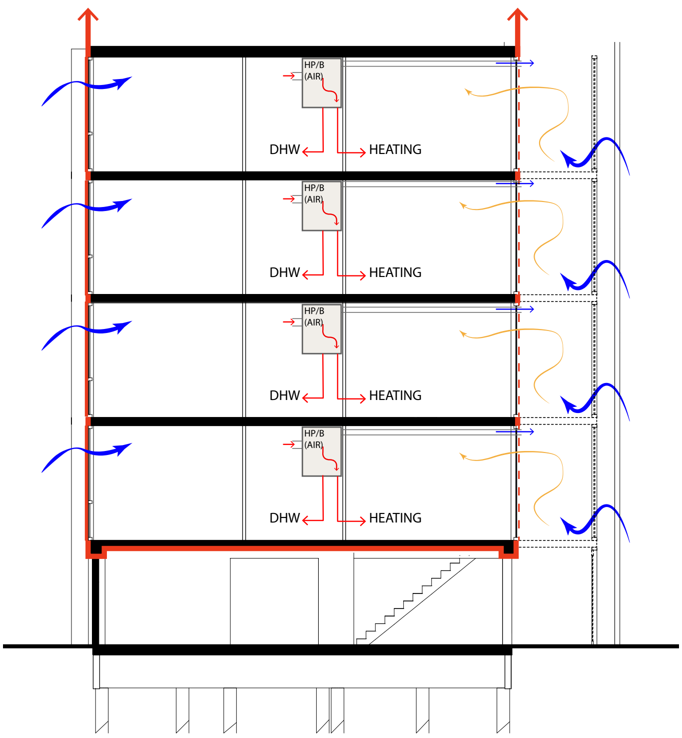
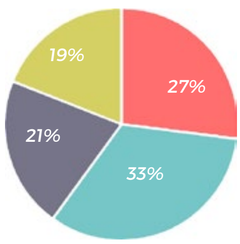


Figure 5.37: Section for retrofitted existing dwellings



EPC:	0.42 (A++)
Energy demand post retrofit:	32kWh/m²/a
Energy demand pre retrofit:	214kWh/m²/a
Energy reduction:	85%

Figure 5.38 Final Uniec results

TOP-UP DWELLINGS CONSTRUCTION

A lightweight construction system with the possibility for prefabrication was sought after for the design of the Top-up. Taking precedents from the Top-up case-study research, one of the lightest construction systems used was a timber platform construction with use of timber box elements and CLT panels. Technical specification for the timber box elements were taken from Lignatur, a company specializing in timber box elements a providing products that conform with not only the thermal requirements, but also fire, acoustic and structural ones; above all it is a lightweight system ideally suited for Top-up. Moreover, the loading and weight specification were used in the structural calculation for the beam, which is laid out in more detail in Appendix B. Standard CLT panels, a relatively heavier component, was used for the first level of the Top-up to provide the stability of the whole unit. Table 5.12 summarizes the construction elements used.

		ELEMENTS	*WEIGHT*	
ROOF	*1.A*	125	59kg/m²	Standard 5 layer CLT panel (19,34,19,34,19 mm)
	1.B	145	68kg/m²	Standard 5 layer CLT panel (34,21,34,21,34 mm)
WALL	*2.A*	158	74kg/m²	Standard 5 layer CLT panel (30,34,30,34,30 mm)
	2.B	180	43kg/m²	Lignatur timber box element with thermal insulation
FLOOR	*3.A*	160	49kg/m²	Lignatur timber box element Fire safe RE60
	3.B	160	43kg/m²	Lignatur timber box element Fire safe RE60 with thermal insulation
	3.C	180	94kg/m²	Lignatur timber box element thermal and acoustic insulation

Table 5.12: Construction elements

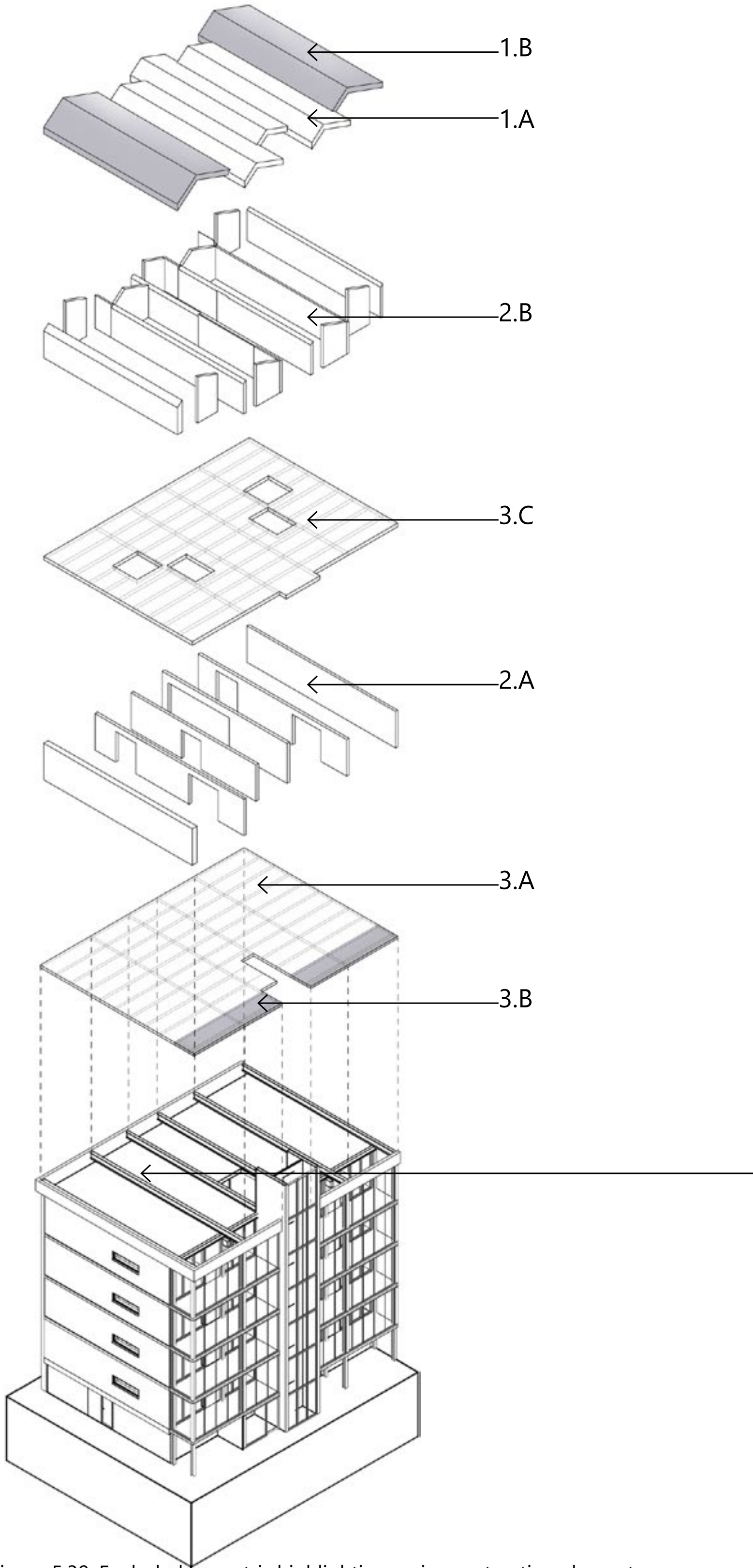


Figure 5.39: Exploded Isometric highlighting main construction elements

Structural connection to Top-up

The connection between the top-up construction and structure was an important consideration given the minimal margin of depth available between the first level of the top up and the existing roof level. The timber box construction system is very flexible in its connection with other structural elements, thus to minimize the top part of the floor element was aligned with the top part of the steel beam as shown in Figure 5.40. In the previous section External Structure it was concluded that Beam three was chosen. However, other options were explored with the top two details shown in the detail. The other option entailed using Beam 1 from Table 5.10, the lightest of the three options, and incorporating the floor element in the bottom half beam to provide an accessible service space for the top-up dwellings using a raised floor. This arrangement could provide maximum flexibility in terms of services, potentially enabling the tenants to decide the spatial arrangement of their homes. The later detail was chosen in the end though, as it minimizes the depth more than the other, thereby keeping the whole retrofit intervention as compact as possible.

Another structural strategy that was contemplated, for which there was not enough time to fully develop and compare, was using the CLT transversal walls used for stability as the spanning structure as well. The necessary openings to make the dwelling plan work would probably require steel strengthening but if successfully developed it could completely eliminate the structural depth currently require and only the building service would need to be accommodated between the intermediary space. The same concept could work with steel trusses, as the concept is about using the full height of the wall to span the necessary distance.

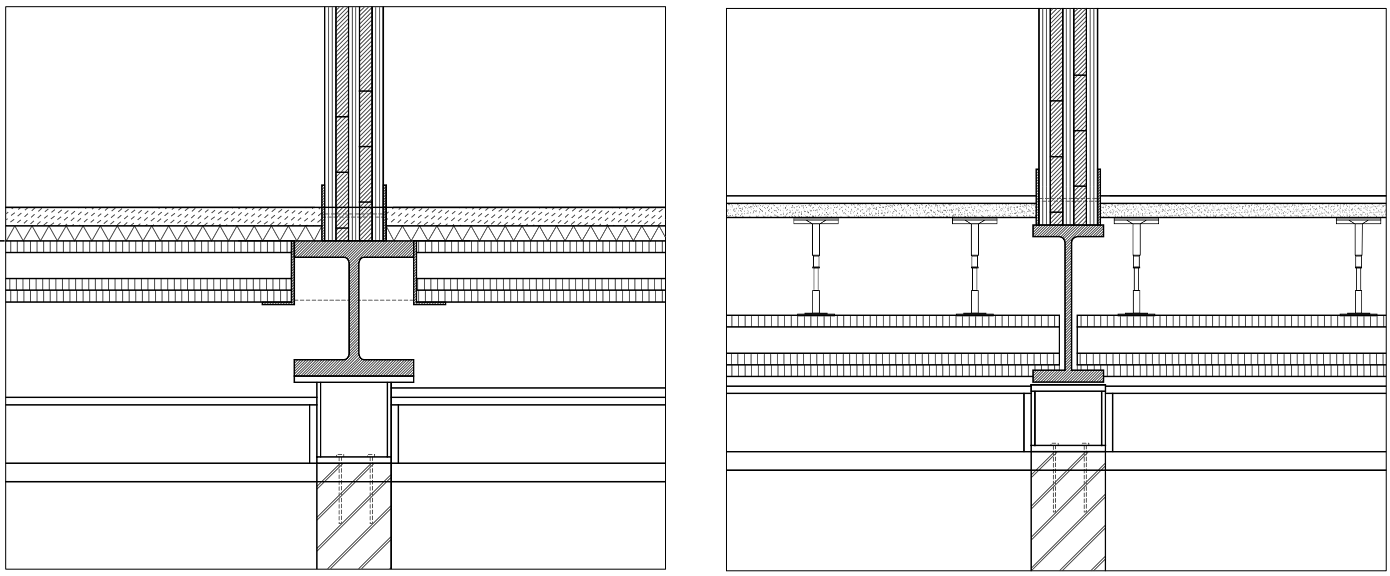


Figure 5.40: Details showing floor-connection options (1:20)

TOP-UP BUILDING SERVICES

The connection of the top-up building services with the existing building was resolved by providing a new service connection that runs along the existing building, see Figure 5.43 Important for this measure was to centralize the dwelling space requiring servicing in terms of plumbing and ducting for all four units, in order to group all pipes in a central duct as shown in the accompanying drawings. By providing a new duct, the services are less limited by spatial restriction of the existing building infrastructure and the service of the existing building can remain untouched. This measure is supported by the case-studies reviewed in the literature study.

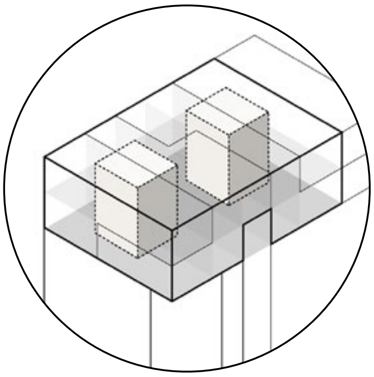


Figure 5.41: Spatial configuration for service spaces.

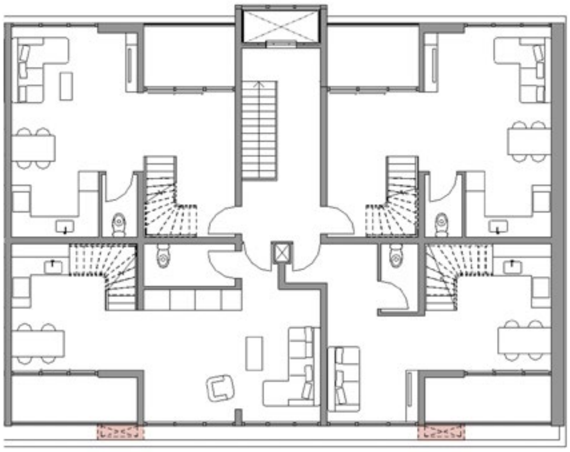


Figure 5.42: Top-up level 1 plan showing builidng service duct

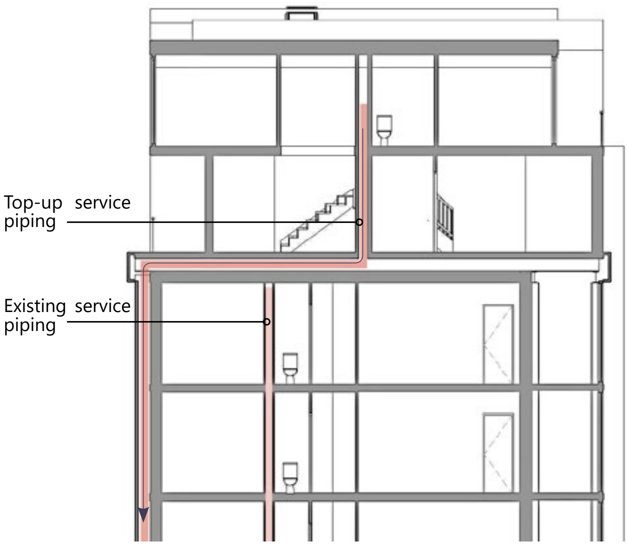


Figure 5.43: Section showing building service routes

FINAL RETROFIT DESIGN CONCLUSION

The final retrofit design used the design strategy selected given the existing building site condition constraints and opportunities together with some of the stakeholder interests, to resolve the design integrations between the design aspects on a detailed and technical level. The final retrofit design provides 50% more dwellings, totalling 48 dwelling with a diversity of 6 different typologies coupled with an energy-reduction of 85% compared to pre-retrofit levels which propel the building from a EPC Label F to A++.

One of the primary objectives was to minimize the depth between the Top-up level and the existing roof level, so as not to compromise the compactness of the accessibility approach. The key parameter which determined this was the structural depth of the beam spanning the distance of the Portiekflat. Using a lightweight construction system based on prefabricated timber-box elements, the dead-weight load could be minimized to use a steel beam with a depth of 380mm spanning 10m. Consequentially, the Top-up is accessible within a compact-form which minimizes its overall extrusion and impact on the street level.

Another key component to the final design of the retrofit was the opportunity created between the external structure and the new circulation core to provide west-facing balconies that were used to enhance the set of retrofit measures by using the balconies as thermal buffer spaces and shading for the existing dwellings. The energy retrofit concept can then be expanded to allow the air-source heat pump to extract pre-heated air from the thermal buffer and use it for space heating and DHW heating. However, this measure was not able to be incorporated in the calculation run with Uniec as this it is outside the scope of the program. Regardless, the set of retrofit measures outlined in Table 5.3 provide the necessary energy-reductions and any additional measure is extra. To verify the effectiveness of the additional buffer spaces, a more specific calculation would need to be run which simulates the energy balance of the building during the year. Unfortunately due to time limitations it was not possible to conduct this calculation.

The next chapter provides the final retrofit drawings which illustrate in detail the solutions that were covered in this chapter.

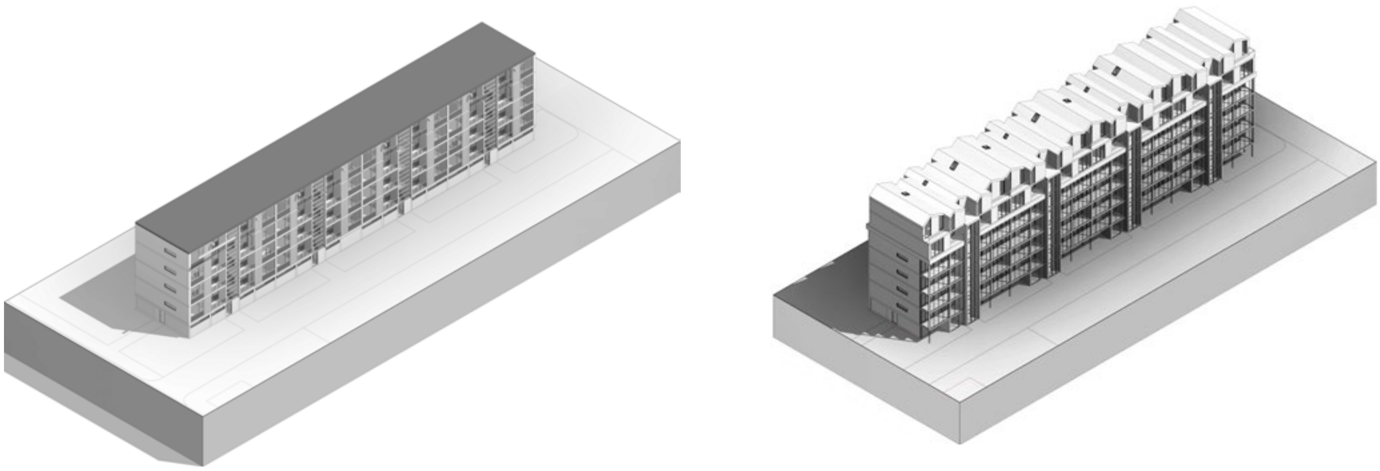
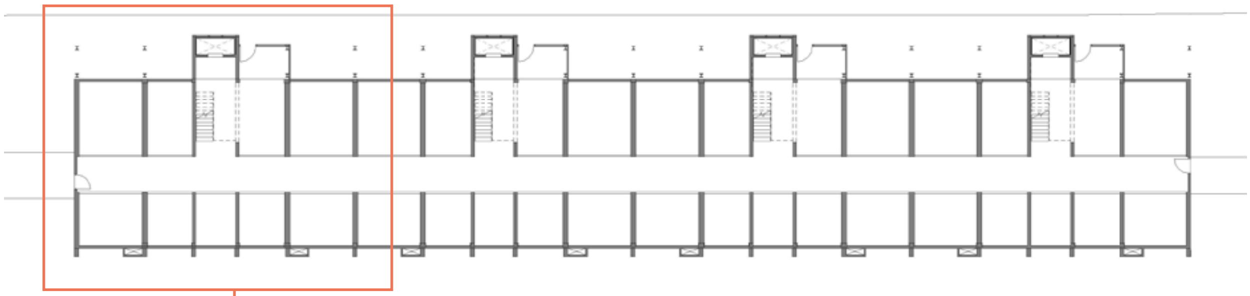


Figure 5.44: Isometric drawing of before and after retrofit for case-study design

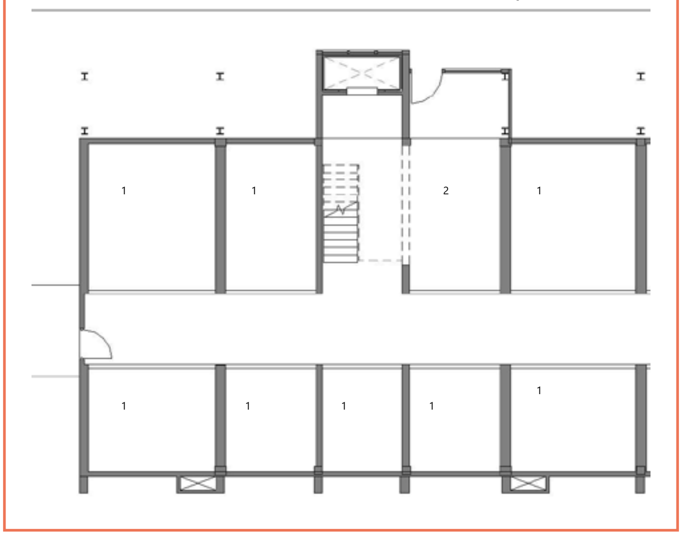
Front perspective

PLANS

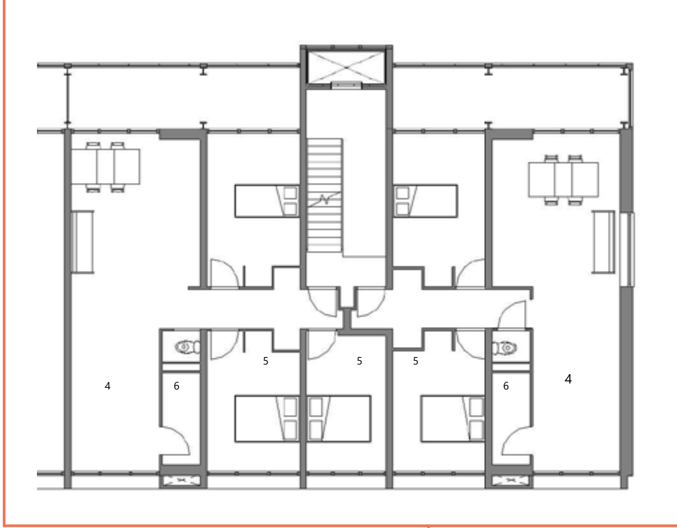


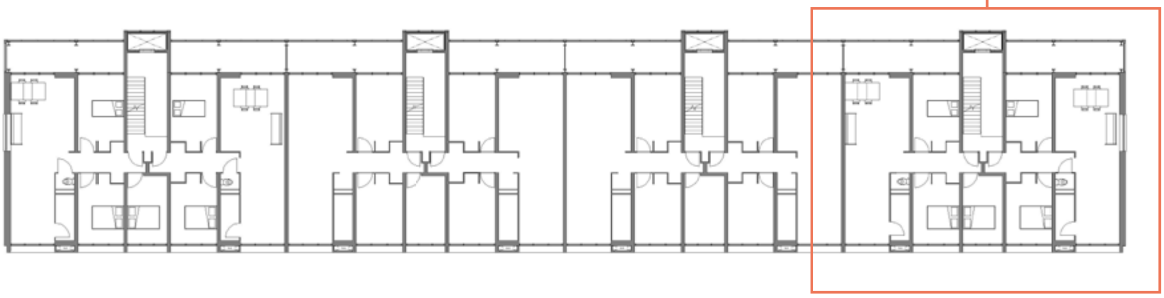
Ground floor 1:400

Ground floor 1:200



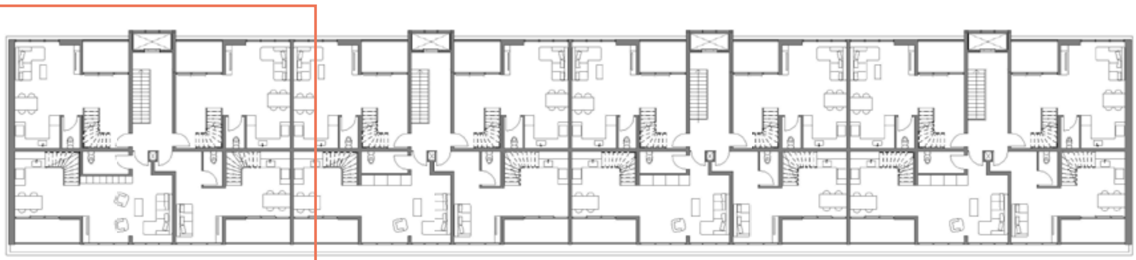
1-4th floor 1:200





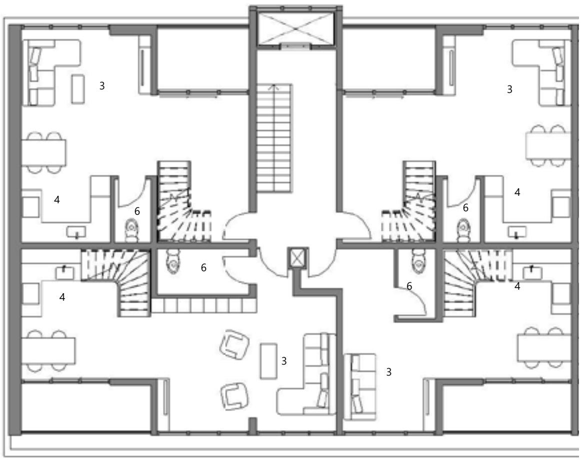
1-4th floor 1:400

1. Storage space
2. Entrance lobby
3. Living room
4. Kitchen
5. Bedroom
6. WC
7. Study room



Top-up 1st Level 1:400

Top-up 1st Level 1:200

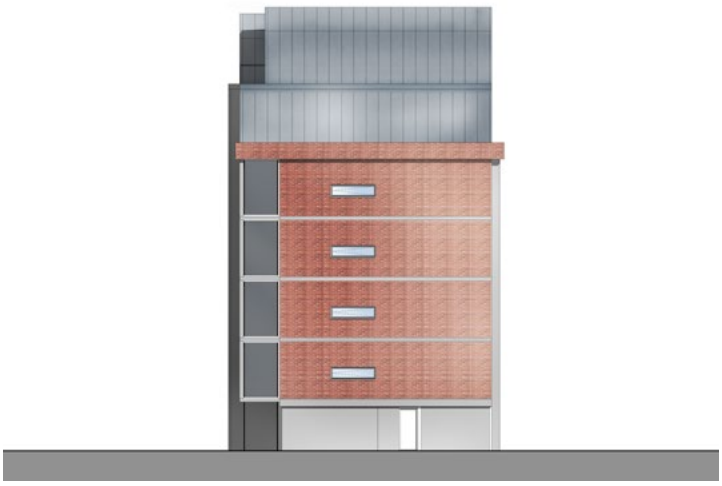


Top-up 2nd Level 1:200

Top-up 2nd Level 1:400

ELEVATIONS

North Elevation

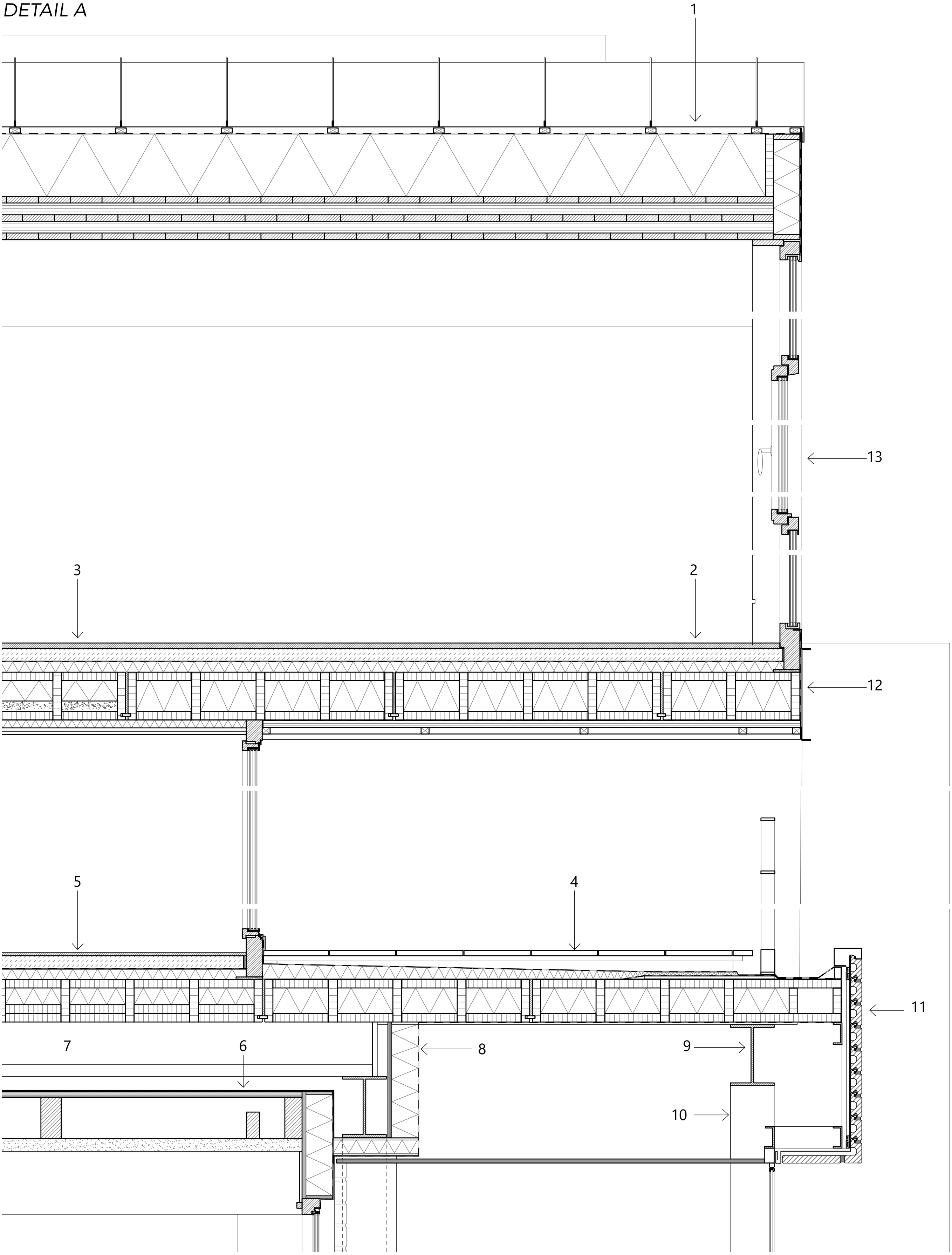


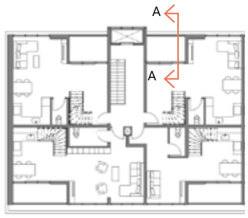
South Elevation

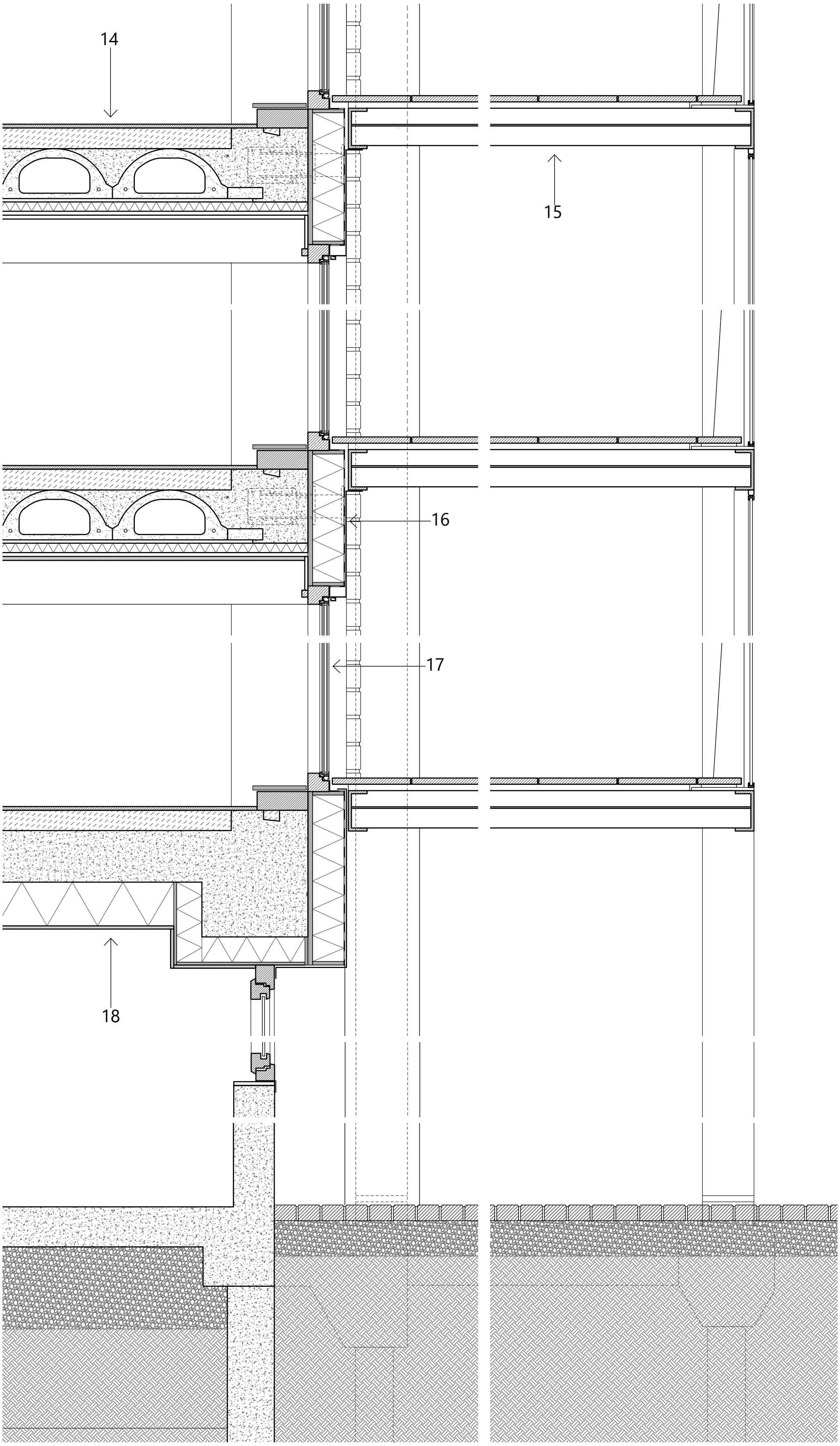
West Elevation

East Elevation

DETAIL A

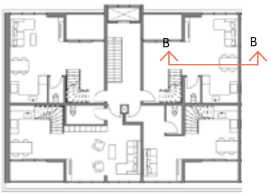




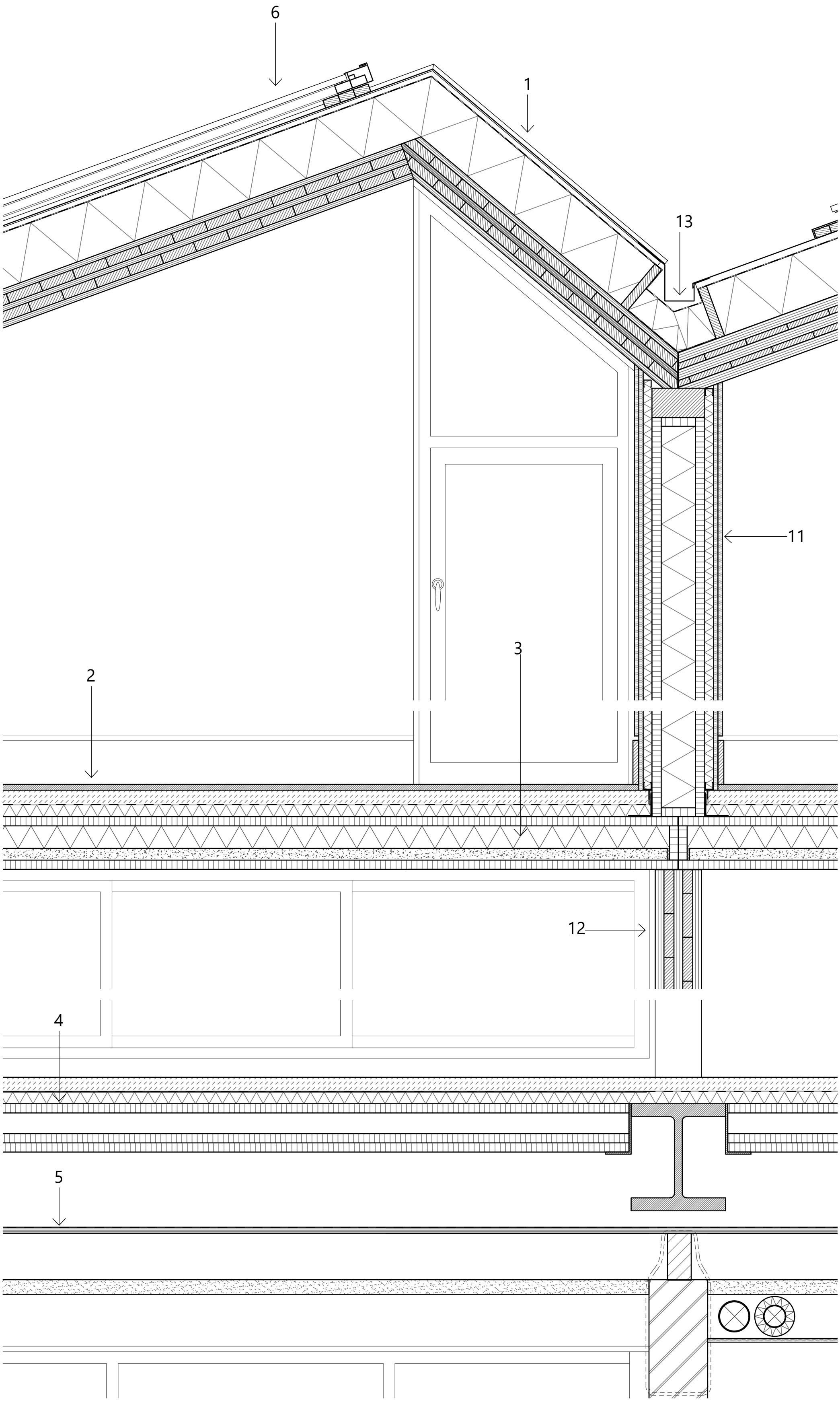


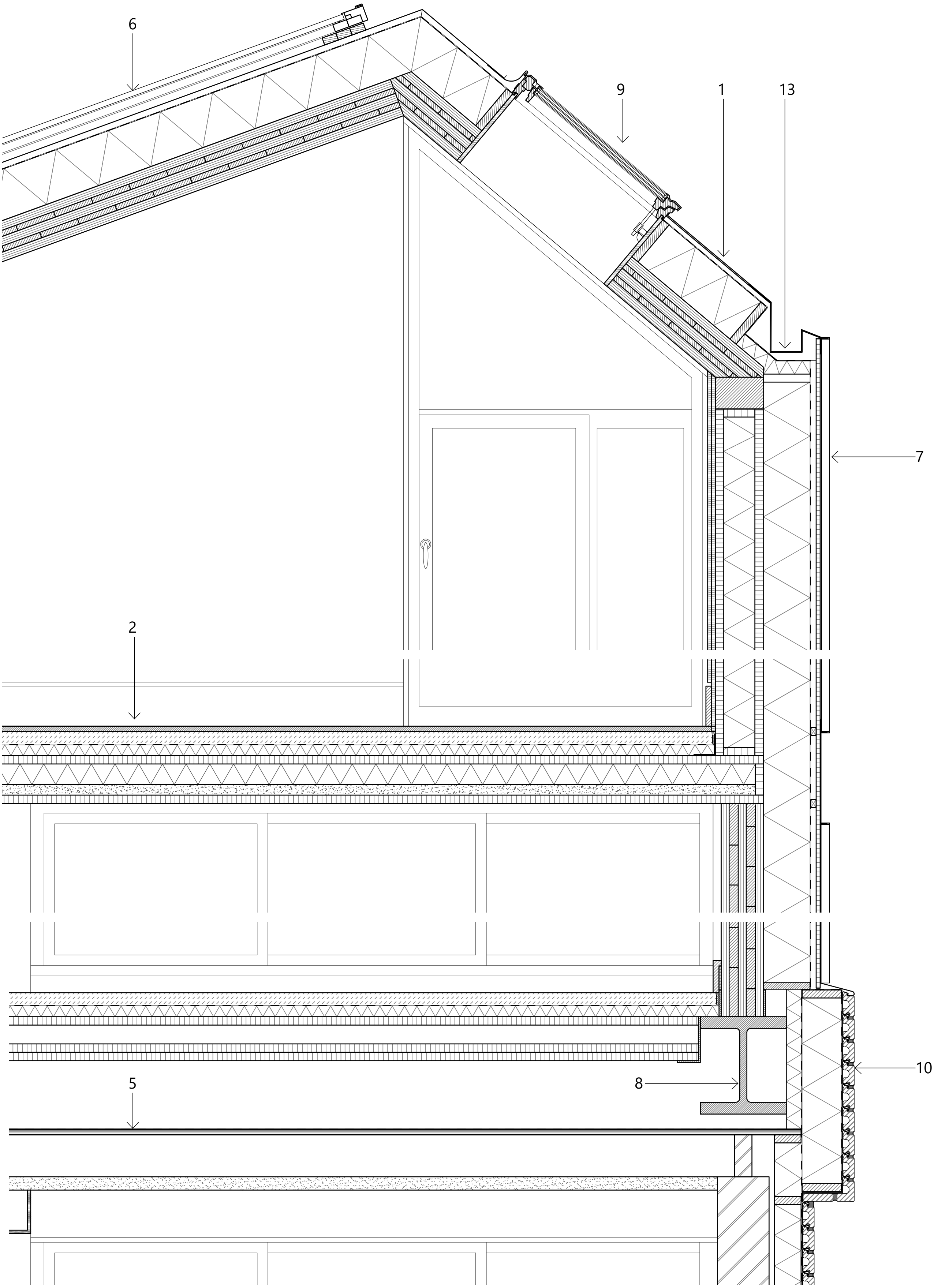
1. Roof construction: zinc cladding; 20mm timber battens; damp proof membrane (DPM); 180mm EPS insulation; CLT roof panel.
2. Top-up Floor construction: 20mm parquet, 50mm screed, 40mm acoustic insulation; 180mm timber box element; 30mm acoustic insulation; 2x12.5mm plasterboard
3. Lignature box element with 50kg/m2 of cement (acoustic)
4. Balcony construction; 20mm laminate flooring; 90mm aluminimum floor structure; 60-20mm EPS insulation; 160mm timber box element with mineral wool insulation
5. RE60 fire safe timber box element.
6. Existing roof construction: bitumen layer, 20mm wood board; 150mm timber beams; 50mm cement-wool board
7. Steel beam 320x360mm
8. Top-up connection: DPM; 100mm EPS insulation; 15mm OSB board
9. Steel beam 165x230mm
10. Steel column
11. Parapet: 45mm slip-brick cladding system; 60mm steel support structure
12. Zinc cladding
13. Triple glazing in wooden frame
14. Floor construction: 12mm new flooring; 65mm new screed; 160mm existing floor construction; 40mm acoustic insulation; 2x12mm plasterboard.
15. Balcony construction: 120mm steel structure supporting 55mm metal deck; 20mm laminate floor
16. Wall panel: zinc cladding; DPM; 100mm EPS insulation; 15mm OSB board.
17. Triple glazing in wooden and aluminium frame
18. 12mm gypsum board; 150mm fibre wool insulation

DETAIL B



1. Roof construction: zinc cladding; 20mm timber battens; damp proof membrane (DPM); 180mm EPS insulation; CLT roof panel.
2. Top-up Floor construction: 20mm parquet, 50mm screed, 40mm acoustic insulation; 180mm timber box element; 30mm acoustic insulation; 2x12.5mm plasterboard
3. Lignatur box element with 50kg/m2 of cement (acoustic)
4. RE60 fire safe timber box element.
5. Existing roof construction: bitumen layer, 20mm wood board; 150mm timber beams; 50mm cement-wool board
6. Solar panel
7. External wall construction: profiled zinc cladding; 15mm OSB board; 20mm timber battens; DPM; 175mm EPS insulation; 180 timber box element with mineral fibre insulation; 2x15mm gypsum board
8. Steel beam 320x360mm
9. Triple glazed operable skylight in aluminium frame
10. Top-up parapet: 45mm slip-brick cladding system; DPM; 150 EPS insulation
11. Internal wall: 2x15mm gypsum board; 30 acoustic insulation (mineral wool); 180mm timber box element with mineral wool
12. Exposed 158mm CLT panel.
13. Rain gutter





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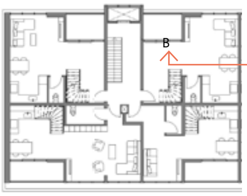
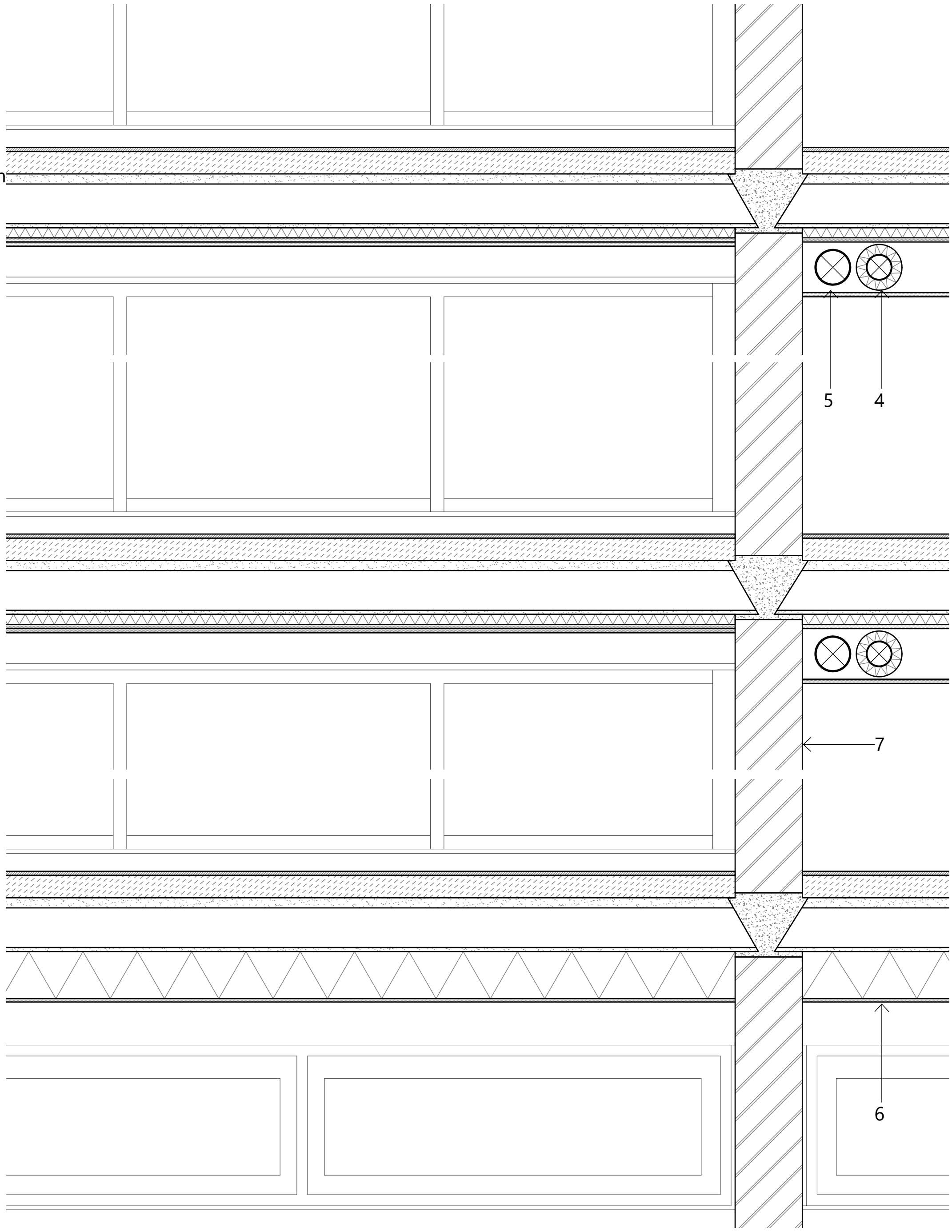
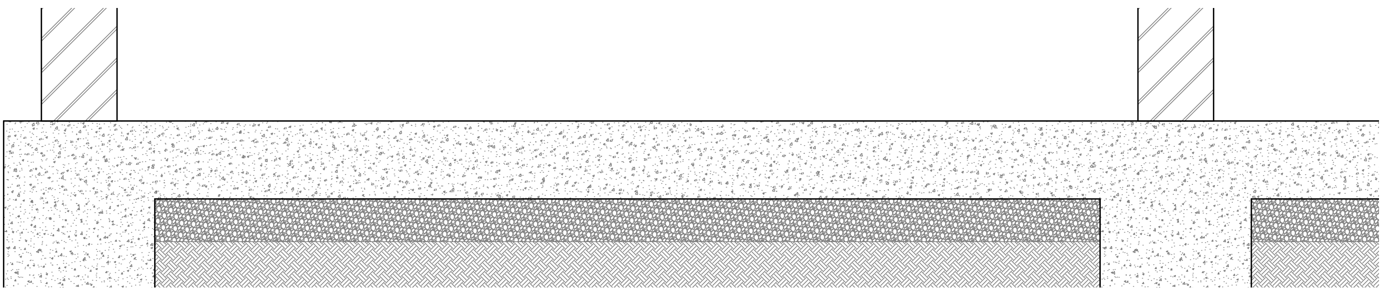
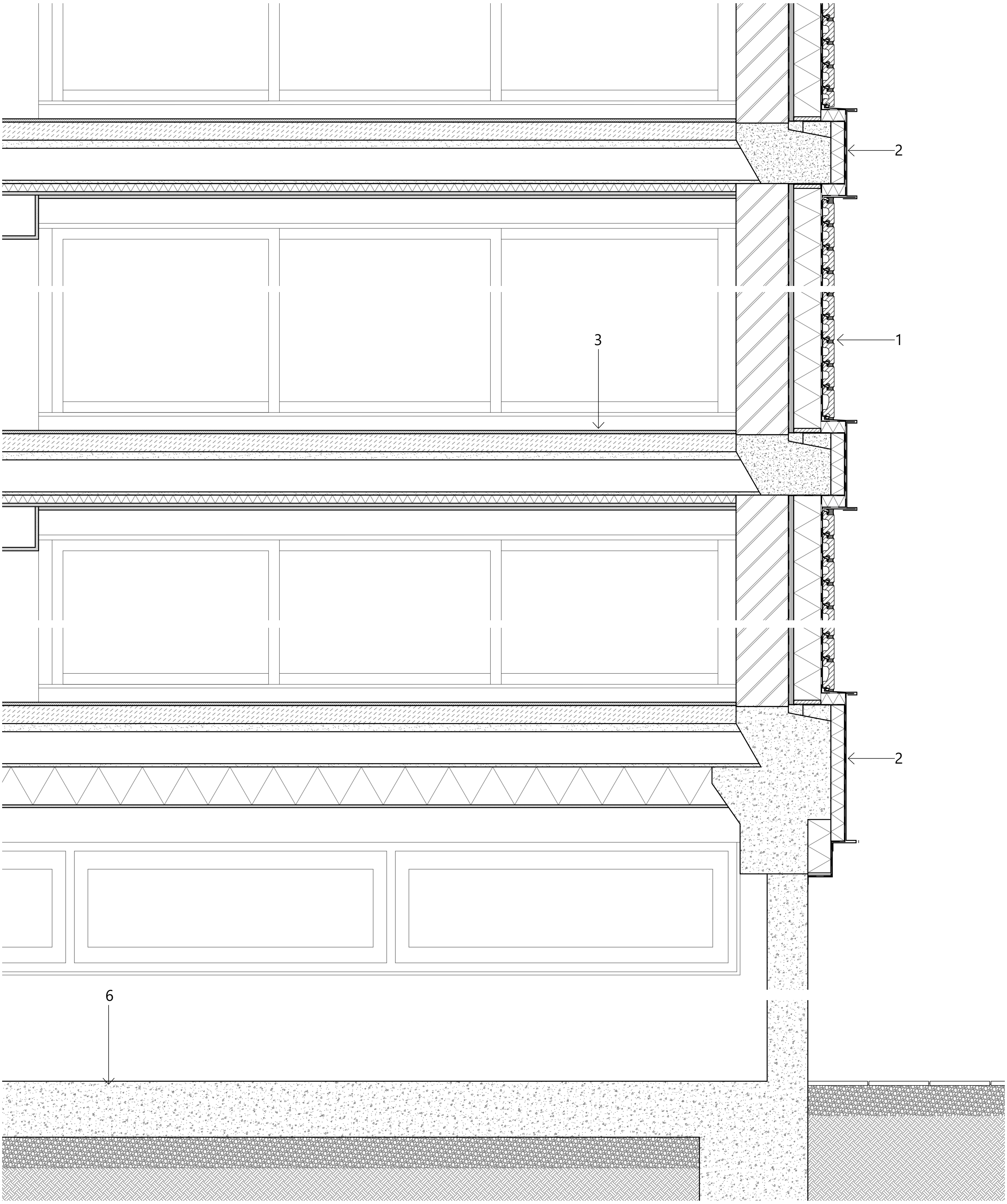
DETAIL B



1. External Wall: 45mm slip-brick cladding system; DPM; 100mm EPS insulation; 20mm OSB board; Existing concrete wall.
2. External wall-floor junction; zinc cladding; DPM; 50mm EPS insulation; existing in situ concrete.
3. Floor construction: 12mm new flooring; 65mm new screed; 160mm existing floor construction; 40mm acoustic insulation; 2x12mm plasterboard.
4. Incoming air duct
5. Exhaust air duct
6. 12mm gypsum board; 150mm fibre wool insulation
7. 200mm existing internal concrete wall
8. 200mm in situ concrete floor slab



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7. CONCLUSION

This thesis sought to explore the possible developments for the building stock of Amsterdam Nieuw-West, a current hotbed of developments that aim to regenerate the urban environment, specifically how two specific forces will start to propel changes to the urban fabric of the region. Firstly, the need to reduce energy consumption in a building stock primarily made up of post-war buildings to achieve the drastic C02 reductions targets; a necessity which applies to all existing pre-energy-regulation buildings. Secondly, a requirement to densify the region, as the growth of Amsterdam is increasing the demand for accommodation at constant growth-rate unmet by the supply side. The thesis sought to organize and quantify both these demands on the building stock to propose a building typology that provided the best opportunity, in other words the most suited, for retrofitting for both energy-saving and densification purposes guided by the following research question which this section aims to answer by summarizing the various results from the sections contain in this thesis.

How can the design of a retrofit measure provide integrated solutions to energy reduction and densification for a suitable residential building typology in the housing stock of Nieuw-West Amsterdam?

To answer the main research question the following products were required:

- Suitable Building Typology Approach

  Using the two urban requirements a strategy was developed to identify the most suitable building typology in the research area that presented the maximum potential effect from both energy-reduction and densification.

- Retrofit Toolbox

  The toolbox is a compilation of different tables that summarize measures and approaches for retrofitting the building envelope, providing accessibility upgrades to enable topping up, structural approaches and housing improvements for 1950's portiekflats and categorized under a specified design aspect. Decision-Making Tool

- Desicion Making Tool

  This tool goes hand in hand with the retrofit tool box and enables the stakeholder to choose the appropriate approaches for a given design aspect. The decisions for each design aspect is prioritized in terms of the starting point of the thesis.

- Design Strategy Brief

  The viable combinations between all approaches in each design aspect, including energy performance, top-up accessibility, top-up structure and housing quality are explored and elaborated on to form the basis of the retrofit design.

The culmination of these products informed the final product, the retrofit design for the Portiekflat of Bouwen Erwoutszstraat, in which technical measures were used to resolve the other design aspects such as construction and building services. However, most important for answering the research question was identifying the design aspects which the design needed to prioritize to produce a systematic method combining different approaches using their underlying decision prioritized, these included:

- Energy Performance: the set of measures that target the building envelope and building services
- Accessibility: a set of approaches that specifically deal with the vertical circulation required for the top-up
- Structure: a set of approaches and measures to provide the structural capacity for the top-up
- Housing quality: a set of improvements that can be made to upgrade existing dwellings.

These aspects were then designed for in isolation in order to identify the set of decisions behind each approach, resulting in the Decision-Making Tool, to then combine them between each other to create the design strategy, supplying the integrated solutions that overcome the main constraints of the building typology, given its layout and construction, site conditions and possible stakeholder interests. The chosen strategy can then form the basis for the retrofit design.

To show the integration of solutions a clear distinction between design aspects on a strategic and technical level had to be made. The main aspects mentioned formed part of the strategic level, and are the initial components that form the design strategy to base the final retrofit design on. The resulting eight strategies demonstrate their direct integration between the Top-up structure and accessibility with, firstly, opportunities to expand on retrofit measures and secondly demonstrate the strategies compatibility with housing quality improvements. At this level, it is possible to demonstrate the main overarching solutions required to continue with the retrofit design and serve as a useful starting point for the designer. The implications of the results at this level allow for a widespread application for the whole building typology that is not necessarily dependant on the area. It is on the following scale, in the detailed phase, where the design solutions for the remaining design aspects can be explored but are applicable for the most part on the individual building can be are based on the building corresponding to the suitable typology, in this case, it was the case-study building on Bouwen Erwoutzstraat. The primary solutions provided at this stage were the structural dimensions to keep the retrofit compact concerning the remodeled circulation core, which required resolving the lightweight construction; as well as providing a top-up dwelling corresponding to the stakeholder's needs. Both of these key resolutions can also be repeated for other portiekflats not only for the same design strategy but some cases, like, for example, with strategy 7, the dwelling typology developed is also replicable.

Recommendations

There are some further recommendations that could be explored in future research that spring from this body of research. This work focussed on finding the best opportunity in the research area to create a retrofit measure for explicitly reducing energy demand and adding more housing capacity using a top-down approach that started with prioritizing the requirements of the urban context and ending with a retrofit design. The process produced several final products that at their core aim to offer more incentive to social housing cooperation by aligning Amsterdam's need to densify with the need to energy-retrofit. In other words, densification can be used as fuel to power and accelerate an almost stagnant energy-retrofit rate which is missing the opportunity to tap into substantial energy-saving potentials.

Regarding the Decision-Making Tool, Retrofit Toolbox and Design Strategy Briefs created on the bases of one case-study and literature study to produce design approaches that can be applied to many different buildings within the typology, a premise of future research could use these tools and apply it to the building stock of the stakeholder. These tools, as discussed in the Design Strategy Conclusion, can help to create a roadmap for social housing corporations to reach their targets, specifically the renovation of their building stock to achieve an average EPC label C. As illustrated in Figure 5.31of the Design Strategy Conclusion, key questions could be asked to identify the part of the Portiekflat stock that requires the least amount of intervention to achieve a top-up, providing opportunities a social housing cooperation might miss if they only considered energy retrofitting. Moreover, the opportunity to top-up might provide the needed capital to energy-retrofit the Portiekflat, as both energy retrofit and densification can work in synergy.

Regarding the Suitable Building Typology approach, as an initial assumption only considered buildings with flat roofs, which in hindsight, taking into account the level of intervention of some possible approaches, could also consider building with gable or sloped roofs. This could change the potential for densification in favour of another typology. However, it would also significantly increase the pool of Portiekflats. An approach would be needed to be added that remodels the roof. Such an addition and development such an approach would allow the tool to incorporate more buildings within the same typology.

Lastly, even though the final design was not a crucial element to answering the research question, rather an outcome of the answers to the research, there are still many elements that can be further developed. Due to the different scales of the thesis from urban to the building, on the technical level, only the areas crucial to the design strategy were explored. In this regard, the design can be further developed, which, as the research showed, is a worthwhile endeavour these retrofit solutions for energy reduction and densification apply to the whole of the typology.

In conclusion, all the products developed during the thesis can either be further designed or applied as they were intended to be, especially useful for the stakeholder. They provide the first attempt to an alternative approach to retrofitting in an effort to align the cities future densification and energy targets to discover and develop that opportunity.

BIBLIOGRAPHY

AgentschapNL. (2013). Infoblad Trias Energetica en energieneutraal bouwen. Den Haag.

Amsterdam, C. o. (2017, July 3). Interactive maps. Opgehaald van https://maps.amsterdam.nl/?LANG=en

Amsterdam, G. (2011). Structuurvisie Amsterdam 2040. Amsterdam: Gemeente Amsterdam .

Amsterdam, G. (2016). Koers 2025 Ruimte voor de stad. 2016: Gemeente Amsterdam.

Anderlesen, G. (2016). Affordable Living in a World City, Business Plan. Amersfoort: Wilco ArtBooks.

Atanasiu, B., Kunkel, S., & Kouloumpi, I. (2013). Criteria to track nZEB activities for housing renovation. COHERENO.

Ballarini, I., Corgnati, S. P., & Corrado, V. (2014, Feburary). Use of reference building to assess the energy saving potentials of residential building stock: The experience of TABULA project. Energy Policy.

Bartlett Quimby, T. (2014, April 11). A Beginner's Guide to the Steel Construciton Manuel. Opgeroepen op October 18, 2017, van BG Structural Engineering: http://www.bgstructuralengineering.com/BGSCM13/BGSCM008/Deflection/BGSCM0080402.htm

BPIE. (2011). Europe's buildings under the microscope. Brussels: Building Performance institute Europe.

BPIE. (2011). Principles for Nearly Zero-Energy Building. BPIE.

Broersma, S., & Fremouw, M. (2015). The City-zen Approach for Urban Energy Master Plans. Delft.

Broersma, S., Fremouw, M., & Andy, v. (2013). Energy Potential Mapping: Visualising Energy Characteristics for the Exergetic Optimisation of the Built Environment. Entropy, pp. 490-506.

Cohereno. (2013). Criteria to track nZEB activities for housing renovation. Brussels: BPIE.

Crone, J. (2001). Dakwoningen met prefab cellen beton casco. Bouwwereld, 40-43.

Crone, J. (2001, May). Dakwoningen met prefab cellenbeton casco. Bouwwereld(10), 40-43.

Dall'O, G., Galante, A., & Pasetti, G. (2012, January). A methodology for evaluating the potential energy savings of retrofitting residential building stocks. Sustainable Cities and Society.

Dall'O', G., Galante, A., & Pasetti, G. (2012). A methodology for evaluating the potential energy savings of retrofitting residential buildings stocks. Sustainable Cities and Society, 12-21.

de Vries, G., & Teeuw, P. (2007). 13 in een dozijn. Aeneas Media.

den Boogert, G., Hakvoort, L., Heit, R., Le Févre, S., Lemmens, B., Mantel, B., . . . de Vries, B. (2014). Energy Atlas Amsterdam Southeast. Amsterdam: City of Amsterdam.

Episcope. (2016). Monito Progress Towards Climate Targets in European Housing Stocks. Darmstadt: Insitute Wohnen und Umwelt GmbH.

Episcope. (2017, September 29). Webtool. Opgehaald van Tabula WebTool: http://webtool.building-typology.eu/#bm

Fuchs, C. (2017, MAR-APR). Additional Storeysin Wood Construction - An Exemplary Project in Zurich. Detail, 62-68.

Haytink, T. G., Geurts, B., & Falcon, H. (2015). Onderzoek energiezuinige renovatiewoningen Label B/A. Rijksdienst voor Ondernemend Nederland.

Hermelink, A., & Muller, A. (2011). Economics of Deep Renovation. Berlin: Ecofys.

Konstantinou, T. (2014). Facade Refurbishment Toolbox, Supporting the Design of Residential Energy Upgrades. Delft: TU Delft.

Koopman, F. W. (2007). General Overview of the Problems, Needs and Solutions in the Dutch Urban Building Envelopes. Amsterdam: IOS Press.

Ma, Z., Cooper, P., Daly, D., & Ledo, L. (2012, August). Existing Building Retrofits: Methodology and state-of-the-art. Energy and Buildings.

Nieman. (2015). Onderzoek Energiezuinige Renovatiewoningen Label B/A. Utrecht: Rijksienst voor Ondernemend Nederland.

Richarz, C., & Schulz, C. (2013). Energy Efficiency Refurbishments. Detail.

Schittich, C. (2011). Building Skins . Munich: Detail.

ter Borch, I. (2007). Bewoond optoppen met staalframebouw. Zoetermeer: Bouwen met Staal.

Tillie, N., Aarts, M., Marijnissen , M., Stenhuijs, L., Borsboom, J., Rietveld, E., . . . Visschers , J. (2012). Rotterdam - People Make The Inner City. Rotterdam: Mediacenter Rooterdam.

Tillie, N., van den Dobbelsteen, A., Doepel, D., de Jager, W., Joubert, M., & Mayenburg, M. (2009). REAP Rotterdam Energy Approach and Planning. Rotterdam: Duurzaamuitgeven.nl.

Urge-Vorsatz, D., Arena, D., Tirado Herrero, S., & Butcher, A. (2010). Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungry. European Climate Foundation.

Van de Voorde , S., Wouters, I., & Bertels, I. (2015). Post-War Building Materials. Brussels: Ae-Lab.

van Overveld, M., van der Graaf, P., S. Eggink-Eilander, & Berghuis, M. (2011). Praktijkboek Bouwbesluit 2012. Den Haag: Sdu Uitgevers Bv.

Verburg, W. (2000). Bouwen op Top Locaties. Rotterdam: Bouwen met Staal.

Verhoef, L., Hendriks, N., van Nunen , H., & Laurs, R. (2007). Creating Flexibility for Better Use of Space in Dwellings in Multi-storey Building. Amsterdam: IOS Press.

9. Appendix

APPENDIX A

Neighbourhood	Block number	Function	House typology	Stakeholder	S. classification	No. of Dwellings	Year of construction	Storeys number	Type of roof	Footprint m2
Buurt 9	18652	Residential	Rowhouses	Owner Occupied	Stadgenoot	32	1955	3	Box Gable	1647
Buurt 9	18654	Residential	Rowhouses	Social Rental	Stadgenoot	32	1955	3	Box Gable	1789
Buurt 9	18653	Residential	Rowhouses	Social Rental	Stadgenoot	32	1955	3	Box Gable	1539
Buurt 9	18788	Residential	Rowhouses	Social Rental	Stadgenoot	35	1955	3	Box Gable	1915
Buurt 9	18789	Residential	Rowhouses	Social Rental	Stadgenoot	34	1955	3	Box Gable	1918
Buurt 9	21317	Residential	Multifamily house	Social Rental	Ymere	58	2005	8	Sloped	2513
Buurt 9	19090	Residential	Rowhouses	Social Rental	Stadgenoot	16	1956	2	Flat	689
Buurt 9	19089	Residential	Rowhouses	Social Rental	Stadgenoot	16	1956	2	Flat	685
Buurt 9	19055	Residential	Rowhouses	Social Rental	Stadgenoot	17	1956	2	Flat	752
Buurt 9	17990	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	384
Buurt 9	17957	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	371
Buurt 9	17958	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	392
Buurt 9	17989	Residential	Rowhouses	Social Rental	Stadgenoot	7	1955	3	Box Gable	367
Buurt 9	17956	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	290
Buurt 9	19636	Residential	Rowhouses	Owner Occupied		8	2006	3	Flat	463
Buurt 9	16766	Residential	Rowhouses	Owner Occupied		8	2006	3	Flat	488
Buurt 9	19200	Residential	Rowhouses	Owner Occupied		8	2006	3	Flat	488
Buurt 9	19201	Residential	Rowhouses	Owner Occupied		8	2006	3	Flat	463
Buurt 9	18860	Residential	Rowhouses	Social Rental	Stadgenoot	15	1956	2	Flat	888
Buurt 9	18529	Residential	Rowhouses	Social Rental	Stadgenoot	9	1955	2	Flat	363
Buurt 9	18859	Residential	Rowhouses	Social Rental	Stadgenoot	14	1956	2	Flat	856
Buurt 9	18496	Residential	Rowhouses	Social Rental	Stadgenoot	9	1956	2	Flat	326
Buurt 9	18813	Residential	Rowhouses	Social Rental	Stadgenoot	18	1956	2	Flat	1072
Buurt 9	18566	Residential	Rowhouses	Social Rental	Stadgenoot	9	1956	2	Flat	350
Buurt 9	18414	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	396
Buurt 9	18412	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	356
Buurt 9	18411	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	398
Buurt 9	18415	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	382
Buurt 9	18413	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	298
Buurt 9	16765	Residential	Rowhouses	Owner Occupied		14	2006	3	Flat	822
Buurt 9	19892	Residential	Rowhouses	Owner Occupied		14	2006	3	Flat	886
Buurt 9	23499	Education	Other			1	2005	3	Flat	2438
Buurt 9	18495	Residential	Rowhouses	Owner Occupied	Stadgenoot	9	1955	2	Flat	362
Buurt 9	18564	Residential	Rowhouses	Social Rental	Stadgenoot	9	1956	2	Flat	384
Buurt 9	18451	Residential	Rowhouses	Social Rental	Stadgenoot	9	1956	2	Flat	353
Buurt 9	17995	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	377
Buurt 9	17994	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	374
Buurt 9	17993	Residential	Rowhouses	Owner Occupied		8	1955	3	Box Gable	379
Buurt 9	17996	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	384
Buurt 9	17991	Residential	Rowhouses	Social Rental	Stadgenoot	8	1955	3	Box Gable	281
Buurt 9	18531	Residential	Rowhouses	Social Rental	Stadgenoot	9	1955	2	Flat	366
Buurt 9	18530	Residential	Rowhouses	Social Rental	Stadgenoot	9	1956	2	Flat	360
Buurt 9	18535	Residential	Rowhouses	Social Rental	Stadgenoot	9	1956	2	Flat	368
Buurt 9	19292	Residential	Rowhouses	Private Rental		18	2006	4	Flat	1005
Buurt 9	18579	Residential	Apartment blocks Portiekflat	Social Rental	Alliantie	95	1995	9	Flat	1745
Buurt 9	20070	Offices	Multifamily house	Social Rental	Cordaan	50	2001	5	Flat	2265
Buurt 9	19034	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1956	5	Hip	604
Buurt 9	19032	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	56	1956	5	Hip	1067
Buurt 9	19033	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1956	5	Hip	561
Buurt 9	20474	Residential	Multifamily house	Social Rental	Stadgenoot	44	2003	10	Flat	861
Buurt 9	15992	Residential	Multifamily house	Owner Occupied		86	2006	5	Flat	1891
Buurt 9	22265	Residential	Multifamily house	Owner Occupied	Stadgenoot	20	2007	5	Flat	559
Buurt 9	19037	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	64	1966	5	Flat	1386
Buurt 9	21316	Residential	Multifamily house	Unknown		85	2008	8	Flat	1206
Buurt 9	22265	Residential	Multifamily house	Private Rental		24	2006	6	Flat	976
Buurt 9	19294	Residential	Multifamily house	Private Rental		35	2006	6	Flat	991
Buurt 9	19034	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	24	1956	5	Hip	488
Buurt 9	19033	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	24	1956	5	Hip	498
Buurt 9	10319	Residential	Multifamily house	Social Rental	Stadgenoot	5	2003	3	Flat	202
Buurt 9	20433	Residential	Multifamily house	Social Rental	Stadgenoot	9	2003	5	Flat	308
Buurt 9	19341	Residential	Multifamily house	Private Rental		47	1966	5	Flat	1607
Buurt 9	19085	Residential	Rowhouses	Social Rental	Rochdale	5	1955	3	Gable	277
Buurt 9	18766	Residential	Rowhouses	Social Rental	Eigen haard	5	1955	3	Gable	289
Buurt 9	18705	Residential	Rowhouses	Social Rental	Eigen haard	5	1955	3	Gable	296
Buurt 9	19014	Residential	Rowhouses	Social Rental	Stadgenoot	5	1955	3	Gable	291
Buurt 9	19035	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1956	5	Hip	582
Buurt 9	18942	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	55	1956	5	Hip	519
Buurt 9	18591	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1956	5	Hip	526
Buurt 9	16752	Residential	Multifamily house	Social Rental	Stadgenoot	22	2003	7	Flat	566
Buurt 9	18656	Residential	Multifamily house	Social Rental	Stadgenoot	12	2003	5	Flat	514
Buurt 9	19085	Residential	Multifamily house	Social Rental	Rochdale	8	1955	3	Gable	378
Buurt 9	18766	Residential	Multifamily house	Social Rental	Eigen haard	8	1955	3	Gable	385
Buurt 9	18705	Residential	Multifamily house	Social Rental	Eigen haard	8	1955	3	Gable	375
Buurt 9	19014	Residential	Multifamily house	Social Rental	Stadgenoot	8	1955	3	Gable	372
Buurt 9	19035	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	24	1956	5	Hip	469
Buurt 9	18942	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	55	1956	5	Hip	492
Buurt 9	18130	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	24	1956	5	Hip	476
Buurt 9	17992	Residential	Multifamily house	Social Rental	Stadgenoot	5	2003	3	Flat	219
Buurt 9	18705	Residential	Rowhouses	Social Rental	Rochdale	4	1955	3	Gable	229
Buurt 9	22266	Residential	Rowhouses	Social Rental	Eigen haard	4	1955	3	Gable	271
Buurt 9	22267	Residential	Rowhouses	Social Rental	Eigen haard	4	1955	3	Gable	280
Buurt 9	22267	Residential	Rowhouses	Social Rental	Stadgenoot	4	1955	3	Gable	272
Buurt 9	18863	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	48	1956	5	Hip	541
Buurt 9	18166	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	29	1956	5	Hip	565
Buurt 9	18364	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1956	5	Hip	547
Buurt 9	16792	Residential	Multifamily house	Social Rental	Stadgenoot	6	2003	3	Flat	247
Buurt 9	18405	Residential	Multifamily house	Social Rental	Rochdale	8	1955	3	Gable	326
Buurt 9	17985	Residential	Multifamily house	Social Rental	Eigen haard	8	1955	3	Gable	350
Buurt 9	18444	Residential	Multifamily house	Social Rental	Eigen haard	8	1955	3	Gable	347
Buurt 9	17998	Residential	Multifamily house	Social Rental	Stadgenoot	8	1955	3	Gable	361
Buurt 9	18863	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	48	1956	5	Hip	328
Buurt 9	17962	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	17	1956	5	Hip	313
Buurt 9	17999	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	16	1956	5	Hip	326
Buurt 9	16805	Residential	Multifamily house	Social Rental	Stadgenoot	35	2003	10	Flat	812
Buurt 9	23130	Residential	Multifamily house	Private Rental		250	2006	11	Flat	4684
Buurt 7	18826	Residential	Semi- detached house	Owner Occupied		2	1993	3	Flat + Shed	110

Electricity consumption kWh	Use surface m2	kWh/m2	Gas consumption m3	Use surface m2	Consumption average per m2	Heating Energy kWh/m2	Gas CO2 emmisions m3	CO2 emission per dwelling
92598	2409	38.4	41408	2409	17.18887505	167.9	73706	2303.32
92956	2284	40.7	37056	2284	16.22416813	158.5	65960	2061.24
96180	2328	41.3	41344	2541	16.27075954	158.9	73592	2299.76
107966	2573	42.0	49735	2573	19.32957637	188.8	88528	2529.38
92759	2596	35.7	46614	2596	17.95608629	175.4	82973	2440.38
359194	11023	32.6	53808	11023	4.881429738	47.7	95778	1651.348966
52560	1100	47.8	17738	1100	16.12545455	157.5	31574	1973.3525
42928	1111	38.6	19558	1111	17.6039604	172.0	34813	2175.8275
45985	1027	44.8	18200	1027	17.72151899	173.1	32396	1905.647059
19280	584	33.0	10000	584	17.12328767	167.3	17800	2225
26904	584	46.1	10664	584	18.26027397	178.4	18982	2372.74
19816	584	33.9	8616	584	14.75342466	144.1	15336	1917.06
18416	601	30.6	7588	601	12.62562396	123.3	13507	1929.52
24088	602	40.0	12416	602	20.62458472	201.5	22100	2762.56
29840	1040	28.7	8408	1040	8.084615385	79.0	14966	1870.78
33968	1040	32.7	11128	1040	10.7	104.5	19808	2475.98
28912	1040	27.8	9736	1040	9.361538462	91.5	17330	2166.26
30184	1040	29.0	8832	1040	8.492307692	83.0	15721	1965.12
52515	1218	43.1	20720	1218	17.01149425	166.2	36882	2458.773333
18063	594	30.4	12654	594	21.3030303	208.1	22524	2502.68
64778	1224	52.9	21588	1224	17.6372549	172.3	38427	2744.76
23931	678	35.3	9738	678	14.36283186	140.3	17334	1925.96
96840	1482	65.3	30532	1482	20.60188934	201.3	54347	3019.275556
21042	594	35.4	8532	594	14.36363636	140.3	15187	1687.44
26968	616	43.8	11192	616	18.16883117	177.5	19922	2490.22
19744	628	31.4	13184	628	20.99363057	205.1	23468	2933.44
29480	584	50.5	11224	584	19.21917808	187.8	19979	2497.34
22232	670	33.2	10712	670	15.9880597	156.2	19067	2383.42
16112	584	27.6	10464	584	17.91780822	175.0	18626	2328.24
45332	1820	24.9	17668	1820	9.707692308	94.8	31449	2246.36
57022	1820	31.3	16828	1820	9.246153846	90.3	29954	2139.56
			313641		-	-	-	-
22824	639	35.7	11448	639	17.91549296	175.0	20377	2264.16
23544	594	39.6	9864	594	16.60606061	162.2	17558	1950.88
18621	594	31.3	10224	594	17.21212121	168.1	18199	2022.08
13072	584	22.4	8088	584	13.84931507	135.3	14397	1799.58
20152	587	34.3	8160	587	13.9011925	135.8	14525	1815.6
18560	620	29.9	8360	620	13.48387097	131.7	14881	1860.1
23048	602	38.3	9360	602	15.54817276	151.9	16661	2082.6
22016	602	36.6	8328	602	13.83388704	135.1	14824	1852.98
29817	667	44.7	10620	667	15.92203898	155.5	18904	2100.4
20223	665	30.4	11232	665	16.89022556	165.0	19993	2221.44
19089	594	32.1	10746	594	18.09090909	176.7	19128	2125.32
62352	2387	26.1	23958	2387	10.03686636	98.1	42645	2369.18
384864	5795	66.4	89110	5795	15.37704918	150.2	158616	1669.64
455500	7867	57.9	87350	7867	11.10334308	108.5	155483	3109.66
212872	3205	66.4	64098	3205	19.99937598	195.4	114094	4074.801429
150808	3203	47.1	56160	3203	17.53356229	171.3	99965	1785.085714
135945	3193	42.6	57456	3193	17.99436267	175.8	102272	3652.56
154800	4336	35.7	41668	4336	9.609778598	93.9	74169	1685.66
274340	8629	31.8	79550	8629	9.218912968	90.1	141599	1646.5
11892	582	20.4	6936	582	11.91752577	116.4	12346	617.304
273963	6366	43.0	82290	6366	12.92648445	126.3	146476	2288.690625
184586	8665	21.3	53157	8665	6.134679746	59.9	94619	1113.170118
17388	582	29.9	6936	582	11.91752577	116.4	12346	514.42
214356	7145	30.0	63063	7145	8.826172148	86.2	112252	3207.204
212872	3205	66.4	64098	3205	19.99937598	195.4	114094	4753.935
135945	3193	42.6	57456	3193	17.99436267	175.8	102272	4261.32
19915	216	92.2	6760	216	31.2962963	305.7	12033	2406.56
29439	822	35.8	9810	822	11.93430657	116.6	17462	1940.2
171644	7823	21.9	46154	7823	5.899782692	57.6	82154	1747.96
40980	1030	39.8	8867.04	435	20.384	199.1	15783	3156.66624
48328	1030	46.9	18499	1033	17.90803485	174.9	32928	6585.644
50246	1030	48.8	22932	1030	22.26407767	217.5	40819	8163.792
40768	1030	39.6	23582	1030	22.89514563	223.7	41976	8395.192
129690	3153	41.1	55328	3153	17.54773232	171.4	98484	3517.28
112200	3014	37.2	58565	3014	19.43098872	189.8	104246	1895.376364
87720	1559	56.3	26432	1559	16.95445799	165.6	47049	1680.32
70173	1878	37.4	22022	1878	11.72630458	114.6	39199	1781.78
44340	1228	36.1	10500	1228	8.550488599	83.5	18690	1557.5
40980	1030	39.8	12245	597	20.51088777	200.4	21796	2724.5125
48328	1030	46.9	18499	1033	17.90803485	174.9	32928	4116.0275
50246	1030	48.8	22932	1030	22.26407767	217.5	40819	5102.37
40768	1030	39.6	23582	1030	22.89514563	223.7	41976	5246.995
129690	3153	41.1	55328	3153	17.54773232	171.4	98484	4103.493333
112200	3014	37.2	58565	3014	19.43098872	189.8	104246	1895.376364
57350	1392	41.2	29784	1392	21.39655172	209.0	53016	2208.98
16160	470	34.4	6925	470	14.73404255	143.9	12327	2465.3
23330	346	67.4	7028	346	20.31213873	198.4	12510	3127.46
20460	346	59.1	7028	346	20.31213873	198.4	12510	3127.46
19456	346	56.2	6092	337.5	18.05037037	176.3	10844	2710.94
13631	346	39.4	6092	337.5	18.05037037	176.3	10844	2710.94
147984	2740	54.0	57224	2740	20.88467153	204.0	101859	2122.056667
63336	1568	40.4	27160	1568	17.32142857	169.2	48345	1667.062069
61712	1601	38.5	32116	1601	20.05996252	196.0	57166	2041.66
21798	570	38.2	6312	570	11.07368421	108.2	11235	1872.56
14812	545	27.2	10888	545	19.97798165	195.2	19381	2422.58
12989	542	24.0	12016	542	22.1697417	216.6	21388	2673.56
30646	545	56.2	12744	542	23.51291513	229.7	22684	2835.54
21170	542	39.1	10344	542	19.08487085	186.4	18412	2301.54
147984	2740	54.0	57224	2740	20.88467153	204.0	101859	2122.056667
41259	927	44.5	20000	927	21.57497303	210.8	35600	2094.117647
31360	929	33.8	16365	929	17.61571582	172.1	29130	1820.60625
102795	3535	29.1	33250	3535	9.405940594	91.9	59185	1691
1509550	24089	62.7	1000040	24089	41.51438416	62.7	917806	3671.2256
9401	180	52.2	3108	180	17.26666667	168.7	5532	2766.12

Neighbourhood	Block number	Function	House typology	Stakeholder	S. classification	No. of Dwellings	Year of construction	Storeys number	Type of roof	Footprint m2
Buurt 7	18826	Residential	Semi- detached house	Owner Occupied		2	1993	3	Flat + Shed	110
Buurt 7	18158	Residential	Multifamily house	Social Rental	Eigen haard	24	1994	7	Flat	433
Buurt 7	18157	Residential	Multifamily house	Social Rental	Eigen haard	24	1994	7	Flat	438
Buurt 7	18159	Residential	Multifamily house	Social Rental	Eigen haard	24	1994	7	Flat	427
Buurt 7	18826	Residential	Semi- detached house	Owner Occupied		2	1993	3	Flat + Shed	110
Buurt 7	18826	Residential	Semi- detached house	Owner Occupied		2	1993	3	Flat + Shed	110
Buurt 7	18475	Residential	Rowhouses	Owner Occupied		6	1993	3	Shed	276
Buurt 7	18477	Residential	Rowhouses	Owner Occupied		6	1993	3	Shed	302
Buurt 7	18474	Residential	Rowhouses	Owner Occupied		6	1992	3	Shed	380
Buurt 7	18478	Residential	Rowhouses	Owner Occupied		6	1992	3	Shed	309
Buurt 7	18476	Residential	Rowhouses	Owner Occupied		6	1992	3	Shed	297
Buurt 7	18259	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	3	Open Gable	273
Buurt 7	18260	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	3	Open Gable	274
Buurt 7	18300	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	3	Open Gable	263
Buurt 7	18258	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	3	Open Gable	250
Buurt 7	18189	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Open Gable	312
Buurt 7	18192	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Open Gable	352
Buurt 7	18190	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Open Gable	351
Buurt 7	18191	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Open Gable	352
Buurt 7	22268	Residential	Rowhouses	Owner Occupied		4	1957	2	Open Gable	185
Buurt 7	18342	Residential	Rowhouses	Social Rental	Stadgenoot	5	1957	1	Open Gable	313
Buurt 7	22268_	Residential	Rowhouses	Social Rental	Stadgenoot	4	1957	2	Open Gable	219
Buurt 7	22269	Residential	Rowhouses	Owner Occupied		4	1957	2	Open Gable	189
Buurt 7	18341	Residential	Rowhouses	Social Rental	Stadgenoot	5	1957	1	Open Gable	294
Buurt 7	22269_	Residential	Rowhouses	Social Rental	Stadgenoot	4	1957	2	Open Gable	229
Buurt 7	22270	Residential	Rowhouses	Social Rental	Stadgenoot	4	1957	2	Open Gable	179
Buurt 7	18341_	Residential	Rowhouses	Social Rental	Stadgenoot	5	1957	1	Open Gable	286
Buurt 7	22270_	Residential	Rowhouses	Social Rental	Stadgenoot	4	1957	2	Open Gable	229
Buurt 7	22271	Residential	Rowhouses	Owner Occupied		4	1957	2	Open Gable	185
Buurt 7	22271_	Residential	Rowhouses	Social Rental	Stadgenoot	5	1957	1	Open Gable	224
Buurt 7	22271__	Residential	Rowhouses	Social Rental	Stadgenoot	4	1957	2	Open Gable	226
Buurt 7	18035	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	2	Open Gable	259
Buurt 7	18256	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	2	Open Gable	268
Buurt 7	18302	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	2	Open Gable	273
Buurt 7	18388	Residential	Rowhouses	Private Rental		6	1957	2	Open Gable	269
Buurt 7	18401	Residential	Rowhouses	Social Rental	Stadgenoot	12	1957	2	Open Gable	541
Buurt 7	18155	Residential	Rowhouses	Social Rental	Stadgenoot	11	1957	2	Open Gable	479
Buurt 7	18153	Residential	Rowhouses	Social Rental	Stadgenoot	11	1957	2	Open Gable	475
Buurt 7	18154	Residential	Rowhouses	Social Rental	Stadgenoot	11	1957	2	Open Gable	495
Buurt 7	15526	Residential	Rowhouses	Unknown	Stadgenoot	6	2009	3	Open Gable	303
Buurt 7	15524	Residential	Rowhouses	Unknown	Stadgenoot	5	2009	3	Open Gable	247
Buurt 7	15525	Residential	Rowhouses	Unknown	Stadgenoot	5	2009	3	Open Gable	240
Buurt 7	18432	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	3	Box Gable	288
Buurt 7	18390	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	3	Box Gable	267
Buurt 7	18389	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	3	Box Gable	264
Buurt 7	18522	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Box Gable	333
Buurt 7	18482	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Box Gable	324
Buurt 7	18521	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Box Gable	338
Buurt 7	23499	ementary School	Other				1955			2159
Buurt 7	22272	Residential	Rowhouses	Owner Occupied		4	1957	2	Open Gable	183
Buurt 7	18340	Residential	Rowhouses	Social Rental	Stadgenoot	5	1957	1	Open Gable	269
Buurt 7	22272_	Residential	Rowhouses	Social Rental	Stadgenoot	4	1957	2	Open Gable	239
Buurt 7	22273	Residential	Rowhouses	Private Rental		4	1957	2	Open Gable	198
Buurt 7	18339	Residential	Rowhouses	Social Rental	Stadgenoot	5	1957	1	Open Gable	276
Buurt 7	22273_	Residential	Rowhouses	Social Rental	Stadgenoot	4	1957	2	Open Gable	204
Buurt 7	22274	Residential	Rowhouses	Private Rental		4	1957	2	Open Gable	188
Buurt 7	18338	Residential	Rowhouses	Social Rental	Stadgenoot	5	1957	1	Open Gable	296
Buurt 7	22274_	Residential	Rowhouses	Social Rental	Stadgenoot	4	1957	2	Open Gable	233
Buurt 7	18078	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Open Gable	362
Buurt 7	18030	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	3	Open Gable	242
Buurt 7	18183	Residential	Rowhouses	Social Rental	Stadgenoot	6	1957	3	Open Gable	252
Buurt 7	13151	Residential	Rowhouses	Owner Occupied		6	1987	3	Saltbox	234
Buurt 7	13157	Residential	Rowhouses	Social Rental	Stadgenoot	8	1957	3	Open Gable	350
Buurt 7	19096	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Open Gable	438
Buurt 7	16062	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	3	Open Gable	451
Buurt 7	19357	Residential	Rowhouses	Owner Occupied		6	1987	3	Saltbox	343
Buurt 7	15777	Residential	Rowhouses	Owner Occupied		6	1986	3	Saltbox	298
Buurt 7	22275	Residential	Rowhouses	Unknown	Cordaan	6	1988	3	Saltbox	357
Buurt 7	15369	Residential	Rowhouses	Owner Occupied		6	1987	3	Saltbox	359
Buurt 7	15709	Residential	Rowhouses	Social Rental	Rochdale	8	1958	2	Flat	458
Buurt 7	15581	Residential	Rowhouses	Social Rental	Rochdale	20	1958	2	Flat	1244
Buurt 7	12414	Residential	Multifamily house	Social Rental	Stadgenoot	18	2010	4	Flat	1554
Buurt 7	11848_	Residential	Rowhouses	Unknown		12	2010	3	Flat	675
Buurt 7	12415	Residential	Multifamily house	Unknown		18	2010	4	Flat	1361
Buurt 7	11848	Residential	Rowhouses	Unknown		12	2010	3	Flat	662
Buurt 7	12438	Residential	Multifamily house	Unknown		18	2010	4	Flat	1350
Buurt 7	15265	Residential	Rowhouses	Unknown		12	2010	3	Flat	629
Buurt 7	21653	Residential	Multifamily house	Unknown		18	2010	4	Flat	2004
Buurt 7	22276	Residential	Rowhouses	Social Rental	Rochdale	4	1958	2	Flat	213
Buurt 7	22276_	Residential	Rowhouses	Social Rental	Rochdale	4	1958	2	Flat	233
Buurt 7	22276__	Residential	Rowhouses	Social Rental	Rochdale	4	1958	2	Flat	183
Buurt 7	22277	Residential	Rowhouses	Social Rental	Rochdale	4	1958	2	Flat	214
Buurt 7	15290	Residential	Multifamily house	Social Rental	Stadgenoot	12	1962	3	Flat	279
Buurt 7	16540	Residential	Rowhouses	Social Rental	Rochdale	18	1958	2	Flat	908
Buurt 7	15768	Residential	Rowhouses	Social Rental	Rochdale	18	1958	2	Flat	914
Buurt 7	13165	Residential	Rowhouses	Social Rental	Rochdale	18	1958	2	Flat	983
Buurt 7	15767	Residential	Rowhouses	Social Rental	Rochdale	18	1958	2	Flat	903
Buurt 7	13168	Residential	Rowhouses	Social Rental	Rochdale	18	1958	2	Flat	1091
Buurt 7	15700	Residential	Rowhouses	Social Rental	Rochdale	18	1957	2	Flat	1057
Buurt 7	16539	Residential	Semi- detached house	Owner Occupied		6	1963	2	Flat	1382
Buurt 7	22277_	Residential	Rowhouses	Social Rental	Rochdale	4	1958	2	Flat	209
Buurt 7	22277__	Residential	Rowhouses	Social Rental	Rochdale	4	1958	2	Flat	188
Buurt 7	22278	Residential	Semi- detached house	Owner Occupied		1	2007	3	Flat	129
Buurt 7	22278_	Residential	Semi- detached house	Owner Occupied		1	2007	3	Flat	134
Buurt 7	22278__	Residential	Semi- detached house	Owner Occupied		1	2007	3	Flat	135
Buurt 7	22278___	Residential	Semi- detached house	Owner Occupied		1	2007	3	Flat	128
Buurt 7	19113	Residential	Rowhouses	Social Rental	Rochdale	10	1958	2	Flat	405

Electricity consumption kWh	Use surface m2	kWh/m2	Gas consumption m3	Use surface m2	Consumption average per m2	Heating Energy kWh/m2	Gas CO2 emmisions m3	CO2 emission per dwelling
9401	180	52.2	3108	180	17.26666667	168.7	5532	2766.12
95025	2146	44.3	24960	2164	11.53419593	112.7	44429	1851.2
84900	2146	39.6	24384	2164	11.26802218	110.1	43404	1808.48
95525	2149	44.5	29304	2164	13.54158965	132.3	52161	2173.38
9401	180	52.2	3108	180	17.26666667	168.7	5532	2766.12
9401	180	52.2	3108	180	17.26666667	168.7	5532	2766.12
25896	468	55.3	6918	468	14.78205128	144.4	12314	2052.34
22662	468	48.4	6438	468	13.75641026	134.4	11460	1909.94
27048	468	57.8	7062	468	15.08974359	147.4	12570	2095.06
17592	468	37.6	5496	468	11.74358974	114.7	9783	1630.48
17808	500	35.6	7884	500	15.768	154.0	14034	2338.92
17784	480	37.1	6972	480	14.525	141.9	12410	2068.36
14244	548	26.0	12504	548	22.81751825	222.9	22257	3709.52
16044	514	31.2	8766	514	17.05447471	166.6	15603	2600.58
18240	497	36.7	8976	497	18.06036217	176.4	15977	2662.88
13223	670	19.7	11354	670	16.94626866	165.5	20210	2887.16
21105	665	31.7	11137	665	16.74736842	163.6	19824	2831.98
16149	677	23.9	12271	677	18.12555391	177.1	21842	3120.34
22715	644	35.3	12635	644	19.61956522	191.7	22490	3212.9
5979	114.5	52.2	4565	114.5	39.86899563	389.5	8126	2031.425
11880	200	59.4	5665	200	28.325	276.7	10084	2016.74
5979	114.5	52.2	4565	114.5	39.86899563	389.5	8126	2031.425
4521	114.5	39.5	4110	114.5	35.89519651	350.7	7316	1828.95
11352	200	56.8	6955	200	34.775	339.7	12380	2475.98
4521	114.5	39.5	4110	114.5	35.89519651	350.7	7316	1828.95
5688	114.5	49.7	3702	114.5	32.33187773	315.9	6590	1647.39
11352	200	56.8	6955	200	34.775	339.7	12380	2475.98
5388	114.5	47.1	3702	114.5	32.33187773	315.9	6590	1647.39
4620	114.5	40.3	3702	114.5	32.33187773	315.9	6590	1647.39
8472	200	42.4	6466	200	32.33	315.8	11509	2301.896
4620	114.5	40.3	3702	114.5	32.33187773	315.9	6590	1647.39
14256	480	29.7	10938	480	22.7875	222.6	19470	3244.94
19890	480	41.4	9798	480	20.4125	199.4	17440	2906.74
16458	480	34.3	10320	480	21.5	210.0	18370	3061.6
17526	480	36.5	8940	480	18.625	181.9	15913	2652.2
25788	1110	23.2	18192	1110	16.38918919	160.1	32382	2698.48
27244	1009	27.0	18821	1009	18.6531219	182.2	33501	3045.58
24288	998	24.3	20801	998	20.84268537	203.6	37026	3365.98
29497	1009	29.2	20504	1009	20.32111001	198.5	36497	3317.92
26592	750	35.5			#DIV/0!	35.5	16168	2694.656
16150	625	25.8			#DIV/0!	25.8	9819	1963.84
22450	625	35.9			#DIV/0!	35.9	13650	2729.92
25008	480	52.1	10992	480	22.9	223.7	19566	3260.96
15612	480	32.5	9624	480	20.05	195.9	17131	2855.12
20004	480	41.7	9570	480	19.9375	194.8	17035	2839.1
21322	665	32.1	10906	665	16.4	160.2	19413	2773.24
17430	671	26.0	11736	671	17.49031297	170.9	20890	2984.297143
20748	657	31.6	10871	657	16.54642314	161.6	19350	2764.34
					-	-	-	-
4905	114.5	42.8	2942.5	114.5	25.69868996	251.1	5238	1309.4125
4605	200	23.0	5005	200	25.025	244.5	8909	1781.78
4905	114.5	42.8	2942.5	114.5	25.69868996	251.1	5238	1309.4125
7194	114.5	62.8	2947.5	114.5	25.74235808	251.5	5247	1311.6375
6065	200	30.3	7295	200	36.475	356.3	12985	2597.02
7194	114.5	62.8	2947.5	114.5	25.74235808	251.5	5247	1311.6375
3960	114.5	34.6	3065	114.5	26.76855895	261.5	5456	1363.925
7065	200	35.3	7280	200	36.4	355.6	12958	2591.68
3960	114.5	34.6	3065	114.5	26.76855895	261.5	5456	1363.925
18304	480	38.1	8622	480	17.9625	175.5	15347	2192.451429
16344	465	35.1	10512	465	22.60645161	220.8	18711	3118.56
16818	480	35.0	9012	480	18.775	183.4	16041	2673.56
20960	334	62.8	5075	334	15.19461078	148.4	9034	1505.583333
15330	788	19.5	9336	788	11.84771574	115.7	16618	2077.26
21984	665	33.1	10402	665	15.64210526	152.8	18516	2645.08
24240	656	37.0	10934	656	16.66768293	162.8	19463	2780.36
31206	611	51.1	6000	492	12.19512195	119.1	10680	1780
22088	474	46.6	6504	474	13.72151899	134.0	11577	1929.52
31206	611	51.1	16055	611	26.27659574	256.7	28578	4762.983333
35749	553	64.6	6860	553	12.40506329	121.2	12211	2035.133333
21400	588	36.4	13011.2	9416	1.381818182	13.5	23160	2894.992
61820	1331	46.4	37586.56	28120	1.336648649	13.1	66904	3345.20384
27995	3250	8.6		3250		8.6	17021	945.6088889
30954	1495	20.7		1495		20.7	18820	1568.336
63448	3250	19.5		3250		19.5	38576	2143.132444
30954	1495	20.7		1495		20.7	18820	1568.336
85077	2890	29.4		2890		29.4	51727	2873.712
43848	1220	35.9		1220		35.9	26660	2221.632
232332	7549	30.8		7549		30.8	141258	7847.658667
12984	286	45.4	5868	286	20.51748252	200.4	10445	2611.26
12984	286	45.4	5868	286	20.51748252	200.4	10445	2611.26
12984	286	45.4	5868	286	20.51748252	200.4	10445	2611.26
10020	269	37.2	4896	269	18.20074349	177.8	8715	2178.72
15950	538	29.6	12280	538	22.82527881	223.0	21858	1821.533333
42540	1247	34.1	21242	1313	16.17821782	158.0	37811	2100.597778
58662	1124	52.2	24174	1190	20.31428571	198.5	43030	2390.54
50787	1292	39.3	27455	1292	21.25	207.6	48870	2714.994444
57528	1127	51.0	21624	1193	18.12573345	177.1	38491	2138.373333
184946	1262	146.5	24246	1328	18.25753012	178.4	43158	2397.66
52139	1245	41.9	21794	1245	17.50522088	171.0	38793	2155.184444
26775	814	32.9	21320	814	26.19164619	255.9	37950	6324.933333
10020	269	37.2	4896	269	18.20074349	177.8	8715	2178.72
10020	269	37.2	4896	269	18.20074349	177.8	8715	2178.72
7716	348	22.2	5868	286	20.51748252	200.4	10445	10445.04
7716	348	22.2	5868	286	20.51748252	200.4	10445	10445.04
7716	348	22.2	5868	286	20.51748252	200.4	10445	10445.04
7716	348	22.2	5868	286	20.51748252	200.4	10445	10445.04
24090	684	35.2	13190	684	19.28362573	188.4	23478	2347.82

Neighbourhood	Block number	Function	House typology	Stakeholder	S. classification	No. of Dwellings	Year of construction	Storeys number	Type of roof	Footprint m2
Buurt 7	22279	Residential	Semi- detached house	Owner Occupied		1	2007	3	Flat	136
Buurt 7	22279_	Residential	Semi- detached house	Owner Occupied		1	2007	3	Flat	128
Buurt 7	22279__	Residential	Semi- detached house	Owner Occupied		1	2007	3	Flat	129
Buurt 7	22279___	Residential	Semi- detached house	Owner Occupied		1	2007	3	Flat	134
Buurt 7	13192	Residential	Rowhouses	Social Rental	Rochdale	10	1958	2	Flat	451
Buurt 7	22280	Residential	Semi- detached house	Social Rental	Stadgenoot	2	2007	2	Flat	307
Buurt 7	22280_	Residential	Semi- detached house	Social Rental	Stadgenoot	2	2007	2	Flat	299
Buurt 7	13167	Residential	Rowhouses	Social Rental	Rochdale	10	1959	2	Flat	426
Buurt 8	23492	Chuch	Other			1	1959	3		1409
Buurt 8	15566	Residential	Multifamily house	Unknown	Ymere	30	2009	5	Flat	557
Buurt 8	15567	Residential	Rowhouses	Unknown		8	2009	3	Gable	469
Buurt 8	15564	Residential	Multifamily house	Unknown		44	2009	5	M-Shaped/Flat	1001
Buurt 8	15563	Residential	Multifamily house	Unknown	De Key	95	2008	11	Flat	1280
Buurt 8	20789	Residential	Multifamily house	Owner Occupied		28	2002	8	Flat	452
Buurt 8	20789	Residential	Multifamily house	Owner Occupied		28	2002	8	Flat	457
Buurt 8	23493	Nursery Home	Other			1	1973			4745
Buurt 8	18754	School	Other			1	2010			1599
Buurt 8	15553	Residential	Multifamily house	Unknown	Stadgenoot	20	2011	7	Flat	1129
Buurt 8	15436	Residential	Multifamily house	Unknown	Stadgenoot	68	2011	16	Flat	1169
Buurt 8	15568	Residential	Rowhouses	Unknown		8	2009	3	Gable	463
Buurt 8	23499	Day Care Center	Other			1	1997	3	Flat	490
Buurt 8	15565	Residential	Multifamily house	Unknown	Ymere	37	2009	4	M-Shaped	816
Buurt 8	-	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	52	1956	5	Gable	1146
Buurt 8	-	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	52	1956	5	Gable	1200
Buurt 8	430	Residential	Apartment blocks Gallerijflat	Social Rental	Ymere	208	1958	8	Gable	5672
Buurt 8	20794	Residential	Multifamily house	Owner Occupied		28	2002	8	Flat	457
Buurt 8	20794	Residential	Multifamily house	Owner Occupied		28	2002	8	Flat	457
Buurt 8	18790	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	80	1957	5	Flat	1801
Buurt 8	18687	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	55	1957	5	Flat	1073
Buurt 8	23492	Chuch	Other			1	1993	4	Flat	581
Buurt 8	-	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	52	1956	5	Gable	1125
Buurt 8	-	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	52	1956	5	Gable	1239
Buurt 8	18953	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	36	1957	5	Flat	655
Buurt 8	18776	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	68	1957	4	Flat	1376
Buurt 8	18951	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	32	1956	5	Flat	655
Buurt 8	19036	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	76	1956	4	Flat	1295
Buurt 8	18924	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	32	1956	5	Flat	655
Buurt 8	18083	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1956	5	Gable	452
Buurt 8	18978	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	24	1956	5	Gable	561
Buurt 8	18079	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1956	5	Gable	508
Buurt 8	18979	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	24	1956	5	Gable	556
Buurt 8	22942	Supermarket	Other			1	2001	1	Flat	1284
Buurt 8	34	ential/Education	Multifamily house	Owner Occupied		62	2002	16	Flat	1395
Buurt 8	19054	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	26	1956	5	Flat	911
Buurt 8	18127	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	25	1956	5	Flat	472
Buurt 8	18600	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	41	1957	4	Flat	745
Buurt 8	20252	Residential	Multifamily house	Owner Occupied		36	2004	6	Flat	734
Buurt 8	12896	Residential	Multifamily house	Owner Occupied		36	2004	6	Flat	734
Buurt 8	12897	Residential	Multifamily house	Social Rental	Ymere	36	2004	6	Flat	734
Buurt 6	18912	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	137	1957	5	Open Gable	2548
Buurt 6	84	Residential	Multifamily house	Social Rental	De Key	78	2006	8	Flat	1043
Buurt 6	18911	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	80	1959	6	Open Gable	1124
Buurt 6	18571	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	48	1956	5	Flat	1799
Buurt 6	18949	Residential	Multifamily house	Social Rental	Eigen haard	15	1996	4	Flat	427
Buurt 6	18907	Residential	Rowhouses	Owner Occupied		18	1986	3	Open Gable	1160
Buurt 6	13236	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	31	1958	5	Open Gable	594
Buurt 6	4255	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	32	1958	5	Open Gable	615
Buurt 6	19270	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	31	1958	5	Open Gable	634
Buurt 6	19364	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	32	1958	5	Open Gable	593
Buurt 6	13174	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	31	1958	5	Open Gable	634
Buurt 6	19126	Residential	Rowhouses	Owner Occupied		9	1987	3	Saltbox	446
Buurt 6	196	Residential	Rowhouses	Owner Occupied		9	1987	3	Saltbox	344
Buurt 6	22281	Residential	Rowhouses	Owner Occupied		3	1987	3	Saltbox	171
Buurt 6	22281_	Residential	Rowhouses	Owner Occupied		3	1987	3	Saltbox	190
Buurt 6	12875_	Residential	Apartment blocks Portiekflat	Social Rental		45	1957	5	Open Gable	845
Buurt 6	12875	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	45	1957	5	Open Gable	926
Buurt 6	19359	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	45	1957	5	Open Gable	1013
Buurt 6	19115	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	45	1957	5	Open Gable	1047
Buurt 6	19282	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	45	1957	5	Open Gable	908
Buurt 6	180	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	48	1956	5	Flat	1054
Buurt 6	19363	Residential	Multifamily house	Social Rental	Eigen haard	15	1996	4	Flat	427
Buurt 6	16211	Residential	Rowhouses	Social Rental	Eigen haard	4	1959	3	Open Gable	792
Buurt 6	16425	Residential	Rowhouses	Social Rental	Eigen haard	14	1958	3	Open Gable	1418
Buurt 6	16681	Residential	Rowhouses	Social Rental	Eigen haard	14	1958	3	Open Gable	1347
Buurt 6	15835	Residential	Rowhouses	Social Rental	Eigen haard	8	1958	3	Open Gable	315
Buurt 6	16630	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	48	1956	5	Flat	954
Buurt 6	15961	Residential	Multifamily house	Social Rental	Eigen haard	32	1996	6	Flat	477
Buurt 6	15989	Residential	Rowhouses	Social Rental	Eigen haard	8	1958	3	Open Gable	331
Buurt 6	15417	Residential	Rowhouses	Social Rental	Eigen haard	8	1958	3	Open Gable	307
Buurt 6	15880	Residential	Rowhouses	Social Rental	Eigen haard	8	1958	3	Open Gable	302
Buurt 6	15773	Residential	Rowhouses	Social Rental	Eigen haard	8	1958	3	Open Gable	300
Buurt 6	15595	Residential	Rowhouses	Social Rental	Eigen haard	8	1958	3	Open Gable	331
Buurt 6	15418	Residential	Rowhouses	Social Rental	Eigen haard	8	1958	3	Open Gable	319
Buurt 6	16272	Residential	Rowhouses	Social Rental	Eigen haard	8	1958	3	Open Gable	299
Buurt 6	15310	Residential	Multifamily house	Social Rental	Eigen haard	12	1958	3	Dormer	273
Buurt 6	15219	Residential	Multifamily house	Social Rental	Eigen haard	12	1958	3	Dormer	288
Buurt 6	15925	Residential	Multifamily house	Social Rental	Eigen haard	12	1959	3	Dormer	305
Buurt 6	15527	Residential	Multifamily house	Social Rental	Eigen haard	12	1959	3	Dormer	292
Buurt 6	15218	Residential	Multifamily house	Social Rental	Eigen haard	12	1959	3	Dormer	289
Buurt 6	15254	Residential	Multifamily house	Social Rental	Eigen haard	12	1959	3	Dormer	283
Buurt 6	16250	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	12	1959	4	Open Gable	727
Buurt 6	16632	Residential	Rowhouses	Social Rental	Eigen haard	15	1958	3	Open Gable	712
Buurt 6	16145	Residential	Rowhouses	Social Rental	Eigen haard	15	1958	3	Open Gable	720
Buurt 6	15965	Residential	Rowhouses	Social Rental	Eigen haard	15	1958	3	Open Gable	719
Buurt 6	15912	Residential	Rowhouses	Social Rental	Eigen haard	15	1958	3	Open Gable	692
Buurt 6	15907	Residential	Rowhouses	Social Rental	Eigen haard	10	1958	3	Open Gable	396
Buurt 6	15907_	Residential	Rowhouses	Social Rental	Eigen haard	5	1958	3	Open Gable	454

Electricity consumption kWh	Use surface m2	kWh/m2	Gas consumption m3	Use surface m2	Consumption average per m2	Heating Energy kWh/m2	Gas CO2 emmisions m3	CO2 emission per dwelling
8484	348	24.4	3026	348	8.695402299	84.9	5386	5386.28
8484	348	24.4	3026	348	8.695402299	84.9	5386	5386.28
8484	348	24.4	3026	348	8.695402299	84.9	5386	5386.28
8484	348	24.4	3026	348	8.695402299	84.9	5386	5386.28
25850	660	39.2	12610	660	19.10606061	186.6	22446	2244.58
5888	548	10.7	11216	548	20.46715328	199.9	19964	9982.24
5888	548	10.7	11216	548	20.46715328	199.9	19964	9982.24
28020	660	42.5	12900	660	19.54545455	190.9	22962	2296.2
249078	11887	21.0	210360	11887	-	-	-	-
71220	2268	31.4			#DIV/0!	31.4	43302	1443.392
24864	960	25.9			#DIV/0!	25.9	15117	1889.664
146748	3900	37.6			#DIV/0!	37.6	89223	2027.790545
220970	7356	30.0			#DIV/0!	30.0	134350	1414.208
105079	3603	29.2	48165	3603	13.4	130.6	85734	3061.917857
105079	3603	29.2	48165	3603	13.4	130.6	85734	3061.917857
					-	-	-	-
					-	-	-	-
291580	5005	58.3		5005		58.3	177281	8864.032
150804	8634	17.5		8634		17.5	91689	1348.365176
24544	890	27.6			#DIV/0!	27.6	14923	1865.344
			313641		-	-	-	-
99752	5008	19.9			#DIV/0!	19.9	60649	1639.168
101866	3368	30.2	41930	3368	12.4	121.6	74635	1435.296154
101866	3368	30.2	41930	3368	12.4	121.6	74635	1435.296154
1631968	26284	62.1	268163	26284	10.2	99.7	477330	2294.856442
86241	3593.5	24.0	56616	3593.5	15.8	153.9	100776	3599.16
86241	3593.5	24.0	56616	3593.5	15.8	153.9	100776	3599.16
593892	9231	64.3	125190	9231	13.6	132.5	222838	2785.4775
126511	3968	31.9	54132	3968	13.6	133.3	96355	1751.908364
					-	-	-	-
101866	3368	30.2	41930	3368	12.4	121.6	74635	1435.296154
101866	3368	30.2	41930	3368	12.4	121.6	74635	1435.296154
79968	2032	39.4	29472	2032	14.5	141.7	52460	1457.226667
132963	3693	36.0	60452	3693	16.4	159.9	107605	1582.42
95007	2032	46.8	35552	2032	17.5	170.9	63283	1977.58
146832	4104	35.8	68932	4104	16.8	164.1	122699	1614.46
77682	2032	38.2	27168	2032	13.4	130.6	48359	1511.22
50520	1423	35.5	21456	1423	15.1	147.3	38192	1363.988571
35280	1852	19.0	7408	1852	4.0	39.1	13186	549.4266667
51312	1533	33.5	22656	1533	14.8	144.4	40328	1440.274286
66630	1928	34.6	32340	1928	16.8	163.9	57565	2398.55
			284985	30387	-	-	-	-
866512	7415	116.9	72346	7415	9.8	95.3	128776	2077.030323
57512	1746	32.9	36375	1746	20.8	203.5	64748	2490.288462
62825	1518	41.4	31392	1518	20.7	202.0	55878	2235.1104
110741	2160	51.3	37960	2160	17.6	171.7	67569	1648.019512
109620	3374	32.5	28692	3374	8.5	83.1	51072	1418.66
126392	3374	37.5	27288	3374	8.1	79.0	48573	1349.24
123062	3374	36.5	28440	3374	8.4	82.3	50623	1406.2
361543	7038	51.4	157067	7197	21.8	213.2	279579	2040.724526
228626	8950	25.5	75761	8950	8.5	82.7	134855	1728.904872
278668	6746.129202	41.3	118360	6746.1	17.5	171.4	210681	2633.51
95200	2931	32.5	17064	2931	5.8	56.9	30374	632.79
47355	1325	35.7	17064	1325	12.9	125.8	30374	2024.928
67880	1430	47.5	24138	1430	16.9	164.9	42966	2386.98
53958	1579	34.2	37620	1732	21.7	212.2	66964	2160.116129
18360	2016	9.1	9888	2016	4.9	47.9	17601	550.02
61952	1581	39.2	36053	1734	20.8	203.1	64174	2070.14
20248	2016	10.0	9496	2016	4.7	46.0	16903	528.215
65856	1581	41.7	31620	1734	18.2	178.1	56284	1815.6
35028	693	50.5	10404	693	15.0	146.7	18519	2057.68
39030	616	63.4	9036	616	14.7	143.3	16084	1787.12
			6070	270	22.5	219.6	10805	3601.533333
			6070	270	22.5	219.6	10805	3601.533333
101024	2348	43.0	72480	2348	30.9	301.6	129014	2866.986667
101024	2348	43.0	72480	2348	30.9	301.6	129014	2866.986667
94752	2600	36.4	61910	2600	23.8	232.6	110200	2448.884444
88800	2310	38.4	58040	2310	25.1	245.5	103311	2295.804444
126000	2304	54.7	67691	2304	29.4	287.0	120490	2677.555111
34713	2883	12.0	9200	2883	3.2	31.2	16376	341.1666667
49605	1325	37.4	14294	1325	10.8	105.4	25443	1696.221333
42210	1328	31.8	20366	1328	15.3	149.8	36251	9062.87
70644	1974	35.8	38976	2116	18.4	179.9	69377	4955.52
75681	1917	39.5	37854	2121	17.8	174.3	67380	4812.865714
19989	552	36.2	8864	552	16.1	156.9	15778	1972.24
11625	2870	4.1	9498	2870	3.3	32.3	16906	352.2175
85476	2260	37.8	23694	2260	10.5	102.4	42175	1317.97875
18280	552	33.1	10608	552	19.2	187.7	18882	2360.28
24920	552	45.1	14016	552	25.4	248.0	24948	3118.56
22592	552	40.9	11184	552	20.3	197.9	19908	2488.44
19688	552	35.7	8984	552	16.3	159.0	15992	1998.94
22320	552	40.4	11192	552	20.3	198.1	19922	2490.22
24096	552	43.7	9168	552	16.6	162.3	16319	2039.88
21616	552	39.2	11264	552	20.4	199.3	20050	2506.24
15626	426	36.7	11640	426	27.3	266.9	20719	1726.6
34762	426	81.6	11016	426	25.9	252.6	19608	1634.04
18980	426	44.6	9960	426	23.4	228.4	17729	1477.4
14274	426	33.5	12180	426	28.6	279.3	21680	1806.7
13598	426	31.9	8280	426	19.4	189.9	14738	1228.2
16484	426	38.7	8856	426	20.8	203.1	15764	1313.64
31829	1733	18.4	7584	1733	4.4	42.8	13500	1124.96
48416	1103	43.9	20560	1103	18.6	182.1	36597	2439.786667
44864	1104	40.6	19200	1104	17.4	169.9	34176	2278.4
47566	1015	46.9	19248	1078	17.9	174.4	34261	2284.096
46087	960	48.0	22455	960	23.4	228.5	39970	2664.66
23310	608	38.3	11713.33	608	19.3	188.2	20850	2084.97274
11655	304	38.3	5856.66	304	19.3	188.2	10425	2084.97096

Neighbourhood	Block number	Function	House typology	Stakeholder	S. classification	No. of Dwellings	Year of construction	Storeys number	Type of roof	Footprint m2
Buurt 6	16150	Residential	Rowhouses	Social Rental	Eigen haard	9	1958	3	Open Gable	481
Buurt 6	16150_	Residential	Rowhouses	Social Rental	Eigen haard	8	1958	3	Open Gable	507
Buurt 6	16024	Residential	Rowhouses	Social Rental	Eigen haard	9	1959	3	Open Gable	212
Buurt 6	16024_	Residential	Rowhouses	Social Rental	Eigen haard	5	1959	4	Open Gable	343
Buurt 6	15977	Residential	Rowhouses	Social Rental	Eigen haard	9	1959	3	Open Gable	191
Buurt 6	15977_	Residential	Rowhouses	Social Rental	Eigen haard	7	1959	3	Open Gable	357
Buurt 6	22959	Residential	Rowhouses	Social Rental	Eigen haard	3	1959	2	Dormer	181
Buurt 6	16273	Residential	Rowhouses	Social Rental	Eigen haard	10	1959	3	Open Gable	466
Buurt 6	15787	Residential	Rowhouses	Social Rental	Eigen haard	11	1959	3	Open Gable	546
Buurt 6	22959_	Residential	Rowhouses	Social Rental	Eigen haard	3	1959	2	Dormer	145
Buurt 6	15421	Residential	Rowhouses	Social Rental	Eigen haard	10	1959	3	Open Gable	430
Buurt 6	15803	Residential	Rowhouses	Social Rental	Eigen haard	12	1959	3	Open Gable	512
Buurt 4 Oost	18937	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	48	1955	5	Open Gable	975
Buurt 4 Oost	18938	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	48	1955	5	Open Gable	971
Buurt 4 Oost	18939	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	48	1955	5	Open Gable	1041
Buurt 4 Oost	19067	one office	Apartment blocks Gallerijflat	Owner Occupied		93	1959	9	Flat	1404
Buurt 4 Oost	19082	Residential	Multifamily house	Social Rental	Stadgenoot	14	1955	3	Open Gable	593
Buurt 4 Oost	18001	Residential	Multifamily house	Social Rental	Stadgenoot	8	1955	2	Open Gable	261
Buurt 4 Oost	18638	Residential	Rowhouses	Social Rental	Rochdale	16	1954	2	Open Gable	880
Buurt 4 Oost	18637	Residential	Rowhouses	Social Rental	Rochdale	16	1954	2	Open Gable	880
Buurt 4 Oost	18639	Residential	Rowhouses	Social Rental	Rochdale	16	1954	2	Open Gable	880
Buurt 4 Oost	19081	Residential	Multifamily house	Social Rental	Stadgenoot	14	1955	3	Open Gable	593
Buurt 4 Oost	11019	Residential	Multifamily house	Social Rental	Stadgenoot	8	1955	2	Open Gable	261
Buurt 4 Oost	17961	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18934	Residential	Rowhouses	Social Rental	Rochdale	19	1954	2	Open Gable	950
Buurt 4 Oost	17960	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18933	Residential	Rowhouses	Social Rental	Rochdale	19	1954	2	Open Gable	950
Buurt 4 Oost	17959	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18931	Residential	Rowhouses	Social Rental	Rochdale	19	1954	2	Open Gable	950
Buurt 4 Oost	18275	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	24	1954	5	Open Gable	456
Buurt 4 Oost	18417	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18416	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18418	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18087	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	24	1954	5	Open Gable	346
Buurt 4 Oost	18494	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18492	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18493	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18088	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	24	1954	5	Open Gable	363
Buurt 4 Oost	18596	Residential	Multifamily house	Social Rental	Rochdale	14	1955	3	Open Gable	611
Buurt 4 Oost	13194	Residential	Multifamily house	Social Rental	Rochdale	8	1955	2	Open Gable	310
Buurt 4 Oost	18773	Residential	Rowhouses	Social Rental	Rochdale	16	1954	2	Open Gable	854
Buurt 4 Oost	18743	Residential	Rowhouses	Social Rental	Rochdale	16	1954	2	Open Gable	854
Buurt 4 Oost	18590	one office	Rowhouses	Social Rental	Rochdale	16	1955	2	Open Gable	1421
Buurt 4 Oost	18572	Residential	Apartment blocks Gallerijflat	Owner Occupied		75	1958	9	Flat	1176
Buurt 4 Oost	18631	Residential	Multifamily house	Social Rental	Rochdale	14	1955	3	Open Gable	602
Buurt 4 Oost	17970	Residential	Multifamily house	Social Rental	Rochdale	8	1955	2	Open Gable	332
Buurt 4 Oost	18772	Residential	Rowhouses	Social Rental	Rochdale	19	1954	2	Open Gable	809
Buurt 4 Oost	18771	Residential	Rowhouses	Social Rental	Rochdale	19	1954	2	Open Gable	809
Buurt 4 Oost	18997	Residential	Rowhouses	Social Rental	Rochdale	27	1955	2	Open Gable	809
Buurt 4 Oost	18453	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18452	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18489	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18490	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18565	Residential	Rowhouses	Social Rental	Rochdale	8	1955	2	Open Gable	352
Buurt 4 Oost	18594	Residential	Multifamily house	Social Rental	Rochdale	14	1955	3	Open Gable	499
Buurt 4 Oost	17971	Residential	Multifamily house	Social Rental	Rochdale	8	1955	2	Open Gable	305
Buurt 4 Oost	18450	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18449	Residential	Rowhouses	Social Rental	Rochdale	8	1954	2	Open Gable	352
Buurt 4 Oost	18527	Residential	Rowhouses	Social Rental	Rochdale	8	1955	2	Open Gable	352
Buurt 4 Oost	23492	Religious space	Other			1	1954			305
Buurt 4 Oost	22935	Sports	Other			1	1963			499
Buurt 4 Oost	18923	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	28	1954	5	Open Gable	613
Buurt 4 Oost	18925	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	28	1954	5	Open Gable	641
Buurt 4 Oost	19086	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	28	1954	5	Open Gable	609
Buurt 4 Oost	23091	School	Other			1	1972			1719
Buurt 4 Oost	12617	Residential	Apartment blocks Gallerijflat	Unknown	Ymere	47	2009	3	Flat	1908
Buurt 4 Oost	6066	Residential	Apartment blocks Gallerijflat	Owner Occupied		9	2009	3	Flat	444
Buurt 4 Oost	12641	Residential	Apartment blocks Gallerijflat	Unknown	Ymere	35	2009	3	Flat	1408
Buurt 4 Oost	18774	Residential	Apartment blocks Gallerijflat	Owner Occupied		48	1997	7	Flat	1000
Buurt 4 Oost	18610	ants ground floor	Apartment blocks Portiekflat	Social Rental	Eigen haard	49	1954	5	Open Gable	809
Buurt 4 Oost	18113	one office	Apartment blocks Portiekflat	Social Rental	Eigen haard	17	1954	5	Open Gable	392
Buurt 4 Oost	18690	one office	Apartment blocks Portiekflat	Owner Occupied		57	1954	5	Open Gable	1186
Buurt 4 Oost	18541	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	17	1954	5	Open Gable	395
Buurt 4 Oost	18726	Hotel, Retail	Apartment blocks Portiekflat	Owner Occupied		63	1958	5	Flat	2083
Buurt 4 Oost	18891	Residential	Rowhouses	Owner Occupied		12	1989	2	Flat	711
Buurt 4 Oost	19013	Residential	Rowhouses	Owner Occupied		10	1989	2	Flat	604
Buurt 4 Oost	18208	Residential	Rowhouses	Owner Occupied		8	1988	2	Flat	460
Buurt 4 Oost	18928	Residential	Rowhouses	Owner Occupied		12	1989	2	Flat	693
Buurt 4 Oost	19010	Residential	Rowhouses	Owner Occupied		10	1989	2	Flat	588
Buurt 4 Oost	19012	Residential	Rowhouses	Owner Occupied		10	1988	2	Flat	576
Buurt 4 Oost	19011	Residential	Rowhouses	Owner Occupied		10	1988	2	Flat	576
Buurt 4 Oost	18319	Residential	Rowhouses	Owner Occupied		8	1988	2	Flat	449
Buurt 4 Oost	18315	Residential	Multifamily house	Social Rental	Ymere	12	1962	2	Flat	338
Buurt 4 Oost	18775	Residential	Apartment blocks Gallerijflat	Owner Occupied		48	1997	7	Flat	973
Buurt 4 Oost	23495	School	Other				1955			1865
Buurt 4 Oost	11014	Care, Retail	Apartment blocks Portiekflat	Owner Occupied		58	2005	8	Flat	1415
Buurt 5 Noord	23499	ementary School	Other				1976		Flat	1884
Buurt 5 Noord	18197	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	20	1954	4	Flat	674
Buurt 5 Noord	22459	Residential	Rowhouses	Social Rental	Rochdale	4	1954	2	Saltbox	210
Buurt 5 Noord	18193	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	20	1954	4	Flat	674
Buurt 5 Noord	22461	Residential	Rowhouses	Social Rental	Rochdale	4	1954	2	Saltbox	210
Buurt 5 Noord	18231	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	20	1954	4	Flat	674
Buurt 5 Noord	22461_	Residential	Rowhouses	Social Rental	Rochdale	4	1954	2	Saltbox	210
Buurt 5 Noord	18232	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	20	1954	4	Flat	674
Buurt 5 Noord	22460	Residential	Rowhouses	Social Rental	Rochdale	4	1954	2	Saltbox	210
Buurt 5 Noord	18230	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	20	1954	4	Flat	674
Buurt 5 Noord	22460_	Residential	Rowhouses	Social Rental	Rochdale	4	1954	2	Saltbox	210

Electricity consumption kWh	Use surface m2	kWh/m2	Gas consumption m3	Use surface m2	Consumption average per m2	Heating Energy kWh/m2	Gas CO2 emmisions m3	CO2 emission per dwelling
24328.59	576	42.2	11637	576	20.2	197.4	20714	2301.54
21625.41	512	42.2	10344	512	20.2	197.4	18412	2301.54
30172.5	576	52.4	12492	576	21.7	211.9	22236	2470.64
16762.5	320	52.4	6940	320	21.7	211.9	12353	2470.64
21961.125		37.6	13043.25	583.41	22.4	218.4	23217	2579.665
17080.875		37.6	10144.75	453.76	22.4	218.4	18058	2579.665
4425	204	21.7	2690.4	8850	0.3	3.0	4789	1596.304
24975	628	39.8	15184.8	13100	1.2	11.3	27029	2702.8944
35244	720	49.0	21428.352	15168	1.4	13.8	38142	3467.49696
4425	204	21.7	2690.4	8850	0.3	3.0	4789	1596.304
25270	628	40.2	15364.16	12740	1.2	11.8	27348	2734.82048
36396	770	47.3	22128.768	17124	1.3	12.6	39389	3282.43392
93075	2804	33.2	59808	2804	21.3	208.4	106458	2217.88
90100	2804	32.1	55056	2804	19.6	191.8	98000	2041.66
122748	2804	43.8	58703	2804	20.9	204.5	104491	2176.902917
290376	6498	44.7	146382	6498	22.5	220.1	260560	2801.72
35955	1048	34.3	21462	1048	20.5	200.1	38202	2728.74
21249	472	45.0	12096	472	25.6	250.4	21531	2691.36
50382	1199	42.0	24000	1199	20.0	195.5	42720	2670
38513	1193	32.3	22736	1193	19.1	186.2	40470	2529.38
50847	1223	41.6	20576	1223	16.8	164.4	36625	2289.08
35085	1048	33.5	23380	1048	22.3	217.9	41616	2972.6
35085	472	74.3	10664	472	22.6	220.7	18982	2372.74
28416	608	46.7	13488	608	22.2	216.7	24009	3001.08
48659	1461	33.3	27056	1461	18.5	180.9	48160	2534.72
24064	590	40.8	12544	590	21.3	207.7	22328	2791.04
53390	1466	36.4	30020	1466	20.5	200.0	53436	2812.4
25200	608	41.4	11688	608	19.2	187.8	20805	2600.58
58539	1430	40.9	25498	1430	17.8	174.2	45386	2388.76
43175	1380	31.3	29400	1380	21.3	208.1	52332	2180.5
12560	629	20.0	9912	629	15.8	153.9	17643	2205.42
18072	536	33.7	9120	536	17.0	166.2	16234	2029.2
22064	599	36.8	10944	599	18.3	178.5	19480	2435.04
45375	1380	32.9	28248	1380	20.5	200.0	50281	2095.06
17864	635	28.1	9536	635	15.0	146.7	16974	2121.76
20728	590	35.1	12840	590	21.8	212.6	22855	2856.9
18688	608	30.7	10608	608	17.4	170.4	18882	2360.28
57325	1380	41.5	27528	1380	19.9	194.9	49000	2041.66
46650	1048	44.5	21420	1048	20.4	199.7	38128	2723.4
46650	472	98.8	10392	472	22.0	215.1	18498	2312.22
43080	1277	33.7	27455	1277	21.5	210.0	48870	3054.36875
49540	1284	38.6	25056	1284	19.5	190.6	44600	2787.48
44576	1090	40.9	24784	1090	22.7	222.1	44116	2757.22
158424	4594	34.5	15375	4594	3.3	32.7	27368	364.9
43785	1048	41.8	25340	1048	24.2	236.2	45105	3221.8
43785	472	92.8	10184	472	21.6	210.8	18128	2265.94
40732	1378	29.6	24038	1378	17.4	170.4	42788	2251.981053
44099	1440	30.6	28386	1440	19.7	192.6	50527	2659.32
77717	2313	33.6	40068	2313	17.3	169.2	71321	2641.52
19104	608	31.4	10472	608	17.2	168.3	18640	2330.02
20376	608	33.5	11936	608	19.6	191.8	21246	2655.76
23584	599	39.4	11008	599	18.4	179.5	19594	2449.28
18560	608	30.5	10616	608	17.5	170.6	18896	2362.06
26376	599	44.0	11328	599	18.9	184.7	20164	2520.48
56476	1048	53.9	26208	1048	25.0	244.3	46650	3332.16
56476	472	119.7	9304	472	19.7	192.6	16561	2070.14
20552	594	34.6	11088	594	18.7	182.4	19737	2467.08
13568	608	22.3	9416	608	15.5	151.3	16760	2095.06
22376	599	37.4	20163.8	599	33.7	328.8	35892	4486.4455
					-	-	-	-
					-	-	-	-
75328	1812	41.6	37576	1812	20.7	202.6	66885	2388.76
73821	1812	40.7	35952	1812	19.8	193.8	63995	2285.52
64064	1822	35.2	35056	1822	19.2	188.0	62400	2228.56
					-	-	-	-
130002	4591	28.3		4591		28.3	79041	1681.728
40275	1044	38.6		1044		38.6	24487	2720.8
96075	2814	34.1		2814		34.1	58414	1668.96
148372	4512	32.9	51504	4512	11.4	111.5	91677	1909.94
111129	3178	35.0	47040	3178	14.8	144.6	83731	1708.8
36360	1168	31.1	21420	1168	18.3	179.2	38128	2242.8
131452	3914	33.6	75468	3914	19.3	188.4	134333	2356.72
83214	1169	71.2	28033	1169	24.0	234.3	49899	2935.22
974810	9622	101.3	121968	9622	12.7	123.8	217103	3446.08
50472	1030	49.0	17664	1030	17.1	167.5	31442	2620.16
34960	864	40.5	12170	864	14.1	137.6	21663	2166.26
25632	712	36.0	11608	712	16.3	159.3	20662	2582.78
46068	1030	44.7	16944	1030	16.5	160.7	30160	2513.36
15470	853	18.1	11790	853	13.8	135.0	20986	2098.62
26290	864	30.4	13440	864	15.6	152.0	23923	2392.32
24156	864	28.0	13170	864	15.2	148.9	23443	2344.26
29200	698	41.8	12928	698	18.5	180.9	23012	2876.48
21749	578	37.6	17484	578	30.2	295.5	31122	2593.46
205065	4512	45.4	46416	4512	10.3	100.5	82620	1721.26
					-	-	-	-
452884	8975	50.5	130848	8975	14.6	142.4	232909	4015.68
		#DIV/0!	313641		-	-	-	-
39671	1298	30.6	23940	1298	18.4	180.2	42613	2130.66
7397	204	36.3	5123	204	25.1	245.3	9119	2279.735
49606	1424	34.8	26638	1424	18.7	182.7	47416	2370.782
7106	204	34.8	5156	204	25.3	246.9	9178	2294.42
48182	1298	37.1	25020	1298	19.3	188.3	44536	2226.78
7572	204	37.1	5156	204	25.3	246.9	9178	2294.42
49442	1298	38.1	27100	1298	20.9	204.0	48238	2411.9
7771	204	38.1	4652	204	22.8	222.8	8281	2070.14
52522	1298	40.5	25640	1298	19.8	193.0	45639	2281.96
8255	204	40.5	4652	204	22.8	222.8	8281	2070.14

Neighbourhood	Block number	Function	House typology	Stakeholder	S. classification	No. of Dwellings	Year of construction	Storeys number	Type of roof	Footprint m2
Buurt 5 Noord	18233	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	20	1954	4	Flat	674
Buurt 5 Noord	22460__	Residential	Rowhouses	Social Rental	Rochdale	4	1954	2	Saltbox	210
Buurt 5 Noord	17950	Residential	Rowhouses	Social Rental	Rochdale	7	1954	3	Open Gable	314
Buurt 5 Noord	18755	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	96	1954	4	Flat	1862
Buurt 5 Noord	22942	Residential	Apartment blocks Gallerijflat	Social Rental	Rochdale	48	1954	5	Flat	1072
Buurt 5 Noord	18575	Residential	Apartment blocks Portiekflat	Owner Occupied		52	1990	4	Flat	1144
Buurt 5 Noord	18454	Residential	Rowhouses	Owner Occupied		7	1990	2	Saltbox	371
Buurt 5 Noord	18952	Residential	Rowhouses	Owner Occupied		13	1990	2	Saltbox	659
Buurt 5 Noord	18712	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	48	1954	6	Open Gable	963
Buurt 5 Noord	18713	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	60	1954	6	Open Gable	911
Buurt 5 Noord	18990	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	60	1954	6	Open Gable	1008
Buurt 5 Noord	18864	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	60	1954	6	Open Gable	1013
Buurt 5 Noord	18806	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	60	1954	6	Open Gable	870
Buurt 5 Noord	18991	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	48	1954	6	Open Gable	1086
Buurt 5 Noord	18935	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	60	1954	6	Open Gable	806
Buurt 5 Noord	19030	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	48	1954	6	Open Gable	992
Buurt 5 Noord	18961	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	60	1954	6	Open Gable	817
Buurt 5 Noord	19029	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	48	1954	6	Open Gable	1002
Buurt 5 Noord	18959	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	60	1954	6	Open Gable	810
Buurt 5 Noord	18841	Residential	Apartment blocks Gallerijflat	Social Rental	Rochdale	32	1956	5	Flat	1919
Buurt 5 Noord	22935	Sports	Other			9	2001			240
Buurt 5 Noord	18170	Residential	Rowhouses	Social Rental	Rochdale	8	1954	1	Shed	505
Buurt 5 Noord	18995	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	36	1954	5	Open Gable	763
Buurt 5 Noord	18823	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	45	1954	5	Open Gable	786
Buurt 5 Noord	18007	Residential	Rowhouses	Social Rental	Rochdale	6	1954	1	Shed	377
Buurt 5 Noord	18237	Residential	Rowhouses	Social Rental	Rochdale	6	1954	1	Shed	377
Buurt 5 Noord	18236	Residential	Rowhouses	Social Rental	Rochdale	6	1954	1	Shed	359
Buurt 5 Noord	18738	Residential	Rowhouses	Social Rental	Rochdale	4	1954	1	Shed	593
Buurt 5 Noord	22657	Church	Other			1	1972	1		233
Buurt 5 Noord	22960	Care	Other			1	1975	6	Flat	452
Buurt 5 Noord	18161	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	18	1954	5	Open Gable	526
Buurt 5 Noord	18161_	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	15	1954	5	Open Gable	366
Buurt 5 Noord	18169	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	18	1954	5	Open Gable	448
Buurt 5 Noord	18994_	Residential	Apartment blocks Portiekflat	Owner Occupied		12	1961	4	Open Gable	344
Buurt 5 Noord	18994	Residential	Apartment blocks Gallerijflat	Owner Occupied		25	1961	5	Flat	796
Buurt 5 Noord	18015	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	15	1954	5	Open Gable	487
Buurt 5 Noord	18360	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	18	1954	5	Open Gable	535
Buurt 5 Noord	18318	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	15	1954	5	Open Gable	487
Buurt 5 Noord	18360_	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	18	1954	5	Open Gable	535
Buurt 5 Noord	18318_	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	15	1954	5	Open Gable	487
Buurt 5 Noord	18361	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	18	1954	5	Open Gable	535
Buurt 5 Noord	18318__	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	15	1954	5	Open Gable	487
Buurt 5 Noord	18167	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	18	1954	5	Open Gable	551
Buurt 5 Noord	19123	Residential	Apartment blocks Gallerijflat	Owner Occupied		28	1956	5	Flat	742
Buurt 5 Noord	18353	Residential	Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	358
Buurt 5 Noord	18354	Residential	Rowhouses	Social Rental	Rochdale	8	1954	3	Open Gable	268
Buurt 5 Noord	18434	Residential	Rowhouses	Social Rental	Rochdale	8	1954	3	Open Gable	363
Buurt 5 Noord	18435	Residential	Rowhouses	Social Rental	Rochdale	8	1954	3	Open Gable	363
Buurt 5 Noord	18399	Residential	Rowhouses	Social Rental	Rochdale	8	1954	3	Open Gable	363
Buurt 5 Noord	18398	Residential	Rowhouses	Social Rental	Rochdale	8	1954	3	Open Gable	366
Buurt 5 Noord	16772	Residential	Rowhouses	Social Rental	Rochdale	8	1954	3	Open Gable	395
Buurt 5 Noord	19123_	Retail	Other			1	1956	3	Flat	318
Buurt 5 Zuid	8564	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	18	1955	4	Open Gable	426
Buurt 5 Zuid	13191	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	12	1955	4	Open Gable	330
Buurt 5 Zuid	16757	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	18	1955	4	Open Gable	426
Buurt 5 Zuid	19365	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	12	1955	4	Open Gable	416
Buurt 5 Zuid	15972	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1955	5	Open Gable	544
Buurt 5 Zuid	15502	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	35	1955	5	Open Gable	560
Buurt 5 Zuid	22657		Other			1	1954	1	Open Gable	112
Buurt 5 Zuid	15947	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1954	4	Open Gable	488
Buurt 5 Zuid	16102	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	12	1955	4	Open Gable	309
Buurt 5 Zuid	16005	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1954	4	Open Gable	459
Buurt 5 Zuid	16105	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	12	1955	4	Open Gable	358
Buurt 5 Zuid	15946	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1954	4	Open Gable	497
Buurt 5 Zuid	15419	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	12	1954	4	Open Gable	305
Buurt 5 Zuid	15945	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1954	4	Open Gable	428
Buurt 5 Zuid	13169	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	15	1954	4	Open Gable	343
Buurt 5 Zuid	15668	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1954	4	Open Gable	475
Buurt 5 Zuid	23130	Garage	Other			1	1997	1		445
Buurt 5 Zuid	15328	Residential	Rowhouses	Social Rental	Stadgenoot	6	1955	1	Open Gable	327
Buurt 5 Zuid	15119	Residential	Rowhouses	Social Rental	Stadgenoot	6	1955	1	Open Gable	327
Buurt 5 Zuid	15539	Residential	Multifamily house	Social Rental	Ymere	7	2009	4	Saltbox	340
Buurt 5 Zuid	11864	Residential	Multifamily house	Social Rental	Ymere	7	2009	4	Saltbox	340
Buurt 5 Zuid	11926	Residential	Multifamily house	Social Rental	Ymere	7	2009	4	Saltbox	340
Buurt 5 Zuid	22282	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	144
Buurt 5 Zuid	16291		Other			8	1956	1	Flat	1974
Buurt 5 Zuid	16307	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	64	1956	5	Flat	1411
Buurt 5 Zuid	20183	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	32	1954	5	Open Gable	1048
Buurt 5 Zuid	20183_	tail/Supermarket	Apartment blocks Portiekflat	Social Rental	Stadgenoot	41	2007	5	Flat	1254
Buurt 5 Zuid	15542	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	22	2007	4	Flat	855
Buurt 5 Zuid	15541	Residential	Rowhouses	Social Rental		14	2009	3	Open Gable	808
Buurt 5 Zuid	15540	Residential	Rowhouses	Social Rental		13	2009	3	Open Gable	728
Buurt 5 Zuid	20874	Residential	Apartment blocks Gallerijflat	Social Rental		40	1958	4	Flat	816
Buurt 5 Zuid	23493	ial Care Complex	Other	Social Rental			1958			2381
Buurt 5 Zuid	22282_	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	161
Buurt 5 Zuid	16382	Residential	Rowhouses	Social Rental	Stadgenoot	24	1957	4	Open Gable	1263
Buurt 5 Zuid	22282__	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	148
Buurt 5 Zuid	15814	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1955	5	Open Gable	659
Buurt 5 Zuid	15512	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1955	5	Open Gable	645
Buurt 5 Zuid	15866	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1955	5	Open Gable	660
Buurt 5 Zuid	15448	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	28	1956	5	Open Gable	681
Buurt 5 Zuid	16623	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	49	1956	6	Flat	1046
Buurt 5 Zuid	16605	Residential	Multifamily house	Social Rental	Eigen haard	22	1955	3	Dormer	1103
Buurt 5 Zuid	16412	Residential	Multifamily house	Social Rental	Eigen haard	32	1955	3	Dormer	991
Buurt 5 Zuid	16417	Residential	Multifamily house	Social Rental	Eigen haard	28	1955	3	Dormer	1042
Buurt 5 Zuid	23501	Residential	Semi- detached house	Owner Occupied		3	1956	2	Flat	247
Buurt 5 Zuid	22283	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	162

Electricity consumption kWh	Use surface m2	kWh/m2	Gas consumption m3	Use surface m2	Consumption average per m2	Heating Energy kWh/m2	Gas CO2 emmisions m3	CO2 emission per dwelling
49161	1298	37.9	28640	1298	22.1	215.6	50979	2548.96
7726	204	37.9	4652	204	22.8	222.8	8281	2070.14
14217	469	30.3	8295	469	17.7	172.8	14765	2109.3
181472	5127	35.4	89205	5657	15.8	154.0	158785	1654.009375
389550	5507	70.7	284985	30387	9.4	91.6	507273	10568.19375
140980	4230	33.3	46540	4230	11.0	107.5	82841	1593.1
22484	686	32.8	8169	686	11.9	116.3	14541	2077.26
42182	1322	31.9	13026	1261	10.3	100.9	23186	1783.56
110052	2913	37.8	53862	2913	18.5	180.6	95874	1997.3825
96319	3033	31.8	50520	3033	16.7	162.7	89926	1498.76
122732	3606	34.0	61366	3606	17.0	166.2	109231	1820.524667
154876	3643	42.5	62769	3643	17.2	168.3	111729	1862.147
91500	3029	30.2	48557	3029	16.0	156.6	86431	1440.524333
112572	2922	38.5	58416	2922	20.0	195.3	103980	2166.26
105595	2784	37.9	49632	2784	17.8	174.2	88345	1472.416
110880	2924	37.9	52800	2924	18.1	176.4	93984	1958
95011	2784	34.1	52704	2784	18.9	184.9	93813	1563.552
97146	2883	33.7	54432	2883	18.9	184.4	96889	2018.52
103831	2784	37.3	43056	2784	15.5	151.1	76640	1277.328
1390788	6077	228.9	25476	6077	4.2	41.0	45347	1417.1025
9910	449	22.1	54657	449	-	-	-	-
34614	784	44.2	13275	784	16.9	165.4	23630	2953.6875
246284	2951	83.5	71778	2951	24.3	237.6	127765	3549.023333
86256	2339	36.9	48622	2339	20.8	203.1	86547	1923.270222
25368	372	68.2	11598	372	31.2	304.6	20644	3440.74
31548	366	86.2	24468	366	66.9	653.1	43553	7258.84
35505	368	96.5	9300	368	25.3	246.9	16554	2759
41536	497	83.6	11128	497	22.4	218.7	19808	4951.96
52040					-	-	-	-
398244					-	-	-	-
31120	1413	22.0	10746	1413	7.6	74.3	19128	1062.66
18657	1178	15.8	9708	1178	8.2	80.5	17280	1152.016
13657	1307	10.4	8670	1307	6.6	64.8	15433	857.3666667
33240	1078	30.8	8377.75	1078	7.8	75.9	14912	1242.699583
99720	3236	30.8	25133	3236	7.8	75.9	44737	1789.4696
11384	1066	10.7	8490	1066	8.0	77.8	15112	1007.48
17688	1287	13.7	10150	1287	7.9	77.0	18067	1003.722222
13006	1067	12.2	9468	1067	8.9	86.7	16853	1123.536
10872	1314	8.3	14498	1287	11.3	110.0	25806	1433.691111
13100	1067	12.3	8979	1067	8.4	82.2	15983	1065.508
27522	1257	21.9	18846	1257	15.0	146.5	33546	1863.66
13100	1067	12.3	8979	1067	8.4	82.2	15983	1065.508
26059	1307	19.9	14715	1307	11.3	110.0	26193	1455.15
583776	4315	135.3	61980	4315	14.4	140.3	110324	3940.157143
18680	512	36.5	10368	512	20.3	197.8	18455	2306.88
17832	512	34.8	13544	512	26.5	258.4	24108	3013.54
17512	512	34.2	10160	512	19.8	193.9	18085	2260.6
19824	516	38.4	10608	516	20.6	200.8	18882	2360.28
17832	512	34.8	9528	512	18.6	181.8	16960	2119.98
16960	512	33.1	12176	512	23.8	232.3	21673	2709.16
17912	512	35.0	10848	512	21.2	207.0	19309	2413.68
					-	-	-	-
33813	1262	26.8	24915	1262	19.7	192.9	44349	2463.816667
37580	836	45.0	15060	836	18.0	176.0	26807	2233.9
46640	1261	37.0	33084	1261	26.2	256.3	58890	3271.64
37876	941	40.3	19035	941	20.2	197.6	33882	2823.525
107496	2098	51.2	38656	2098	18.4	180.0	68808	2457.417143
65628	1863	35.2	37240	1863	20.0	195.3	66287	1893.92
5304	139	38.2	54642	139	-	-	-	-
48116	1261	38.2	29196	1261	23.2	226.2	51969	2887.16
29728	944	31.5	19045	941	20.2	197.7	33900	2825.008333
41154	1261	32.6	30420	1331	22.9	223.3	54148	3008.2
28798	944	30.5	20846	946	22.0	215.3	37106	3092.156667
52038	1261	41.3	32976	1331	24.8	242.0	58697	3260.96
30084	832	36.2	19056	946	20.1	196.8	33920	2826.64
38947	1261	30.9	30056	1331	22.6	220.6	53500	2972.204444
34074	946	36.0	22095	946	23.4	228.2	39329	2621.94
41534	1261	32.9	29844	1261	23.7	231.2	53122	2951.24
1034180	15421	67.1	2876075	69279	-	-	-	-
7200	233	30.9	8064	233	34.6	338.1	14354	2392.32
15120	240	63.0	14064	240	58.6	572.5	25034	4172.32
25800	801	32.2			#DIV/0!	32.2	15686	2240.914286
25800	801	32.2			#DIV/0!	32.2	15686	2240.914286
25800	801	32.2			#DIV/0!	32.2	15686	2240.914286
4698	204	23.0	3906	204	19.1	187.0	6953	3476.34
38800			15608		-	-	-	-
239679	4684	51.2	105612	4684	22.5	220.3	187989	2937.33375
216644	3047	71.1	42228	3047	13.9	135.4	75166	2348.9325
100942	3100	32.6			#DIV/0!	32.6	61373	1496.896
97834	2675	36.6			#DIV/0!	36.6	59483	2703.776
53499	2022	26.5			#DIV/0!	26.5	32527	2323.385143
57512	1506	38.2			#DIV/0!	38.2	34967	2689.792
68101	2540	26.8	32360	2540	12.7	124.5	57601	1440.02
1034180	15421	67.1	1034180	15421	-	-	-	-
4698	204	23.0	3906	204	19.1	187.0	6953	3476.34
81400	2972	27.4	47586	2972	16.0	156.4	84703	3529.295
4698	204	23.0	3906	204	19.1	187.0	6953	3476.34
95410	1735	55.0	38528	1735	22.2	216.9	68580	2449.28
65163	1959	33.3	38080	1959	19.4	189.9	67782	2420.8
63278	1959	32.3	35280	1959	18.0	175.9	62798	2242.8
58740	1752	33.5	36092	1752	20.6	201.2	64244	2294.42
268719	6275.796066	42.8	61544	6275.796066	9.8	95.8	109548	2235.68
60420	1866	32.4	35616	1866	19.1	186.5	63396	2881.658182
66099	2195	30.1	37120	2195	16.9	165.2	66074	2064.8
67580	2021	33.4	35190	2021	17.4	170.1	62638	2237.078571
30928		#DIV/0!	117565	30088	3.9	38.2	209266	69755.23333
4698	204	23.0	4248	204	20.8	203.4	7561	3780.72

Neighbourhood	Block number	Function	House typology	Stakeholder	S. classification	No. of Dwellings	Year of construction	Storeys number	Type of roof	Footprint m2
Buurt 5 Zuid	22283_	Residential	Semi- detached house	Owner Occupied		2	1955	3	Flat	156
Buurt 5 Zuid	22283__	Residential	Semi- detached house	Owner Occupied		2	1954	2	Flat	154
Buurt 5 Zuid	16454	Residential	Rowhouses	Social Rental	Stadgenoot	11	1955	2	Flat	990
Buurt 5 Zuid	19273	Residential	Rowhouses	Social Rental	Stadgenoot	12	1955	2	Flat	662
Buurt 5 Zuid	18777	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	52	2007	5	Flat	2169
Buurt 5 Zuid	16301	Residential	Multifamily house	Social Rental	Eigen haard	22	1955	3	Open Gable	1433
Buurt 5 Zuid	16479	Residential	Multifamily house	Social Rental	Eigen haard	32	1955	3	Open Gable	1180
Buurt 5 Zuid	16044	Residential	Multifamily house	Social Rental	Eigen haard	28	1955	3	Open Gable	1181
Buurt 5 Zuid	22294	Residential	Semi- detached house	Owner Occupied		2	1955	3	Flat	323
Buurt 5 Zuid	22294_	Residential	Semi- detached house	Owner Occupied		2	1955	3	Flat	327
Buurt 5 Zuid	22284	Residential	Semi- detached house	Owner Occupied		2	1955	3	Flat	135
Buurt 5 Zuid	22284_	Residential	Semi- detached house	Owner Occupied		2	1955	3	Flat	140
Buurt 5 Zuid	11935	Garage	Other			1	1955	1	Flat	164
Buurt 5 Zuid	18778	Garage	Other			1	1955	1	Flat	169
Buurt 5 Zuid	15698	Residential	Rowhouses	Social Rental	Eigen haard	15	1954	3	Open Gable	1105
Buurt 5 Zuid	16149	Residential	Rowhouses	Social Rental	Eigen haard	12	1954	3	Open Gable	1096
Buurt 5 Zuid	15201	Residential	Rowhouses	Social Rental	Eigen haard	14	1954	3	Open Gable	1041
Buurt 5 Zuid	16404	Residential	Rowhouses	Owner Occupied		16	1995	3	Open Gable	1315
Buurt 5 Zuid	16444	Residential	Multifamily house	Social Rental	Eigen haard	26	1955	3	Open Gable	1327
Buurt 5 Zuid	15526	Residential	Multifamily house	Social Rental	Eigen haard	26	1955	3	Open Gable	932
Buurt 5 Zuid	15917	Residential	Multifamily house	Social Rental	Eigen haard	22	1955	3	Open Gable	961
Buurt 5 Zuid	22293	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	334
Buurt 5 Zuid	22293_	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	276
Buurt 5 Zuid	22292	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	283
Buurt 5 Zuid	22284__	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	181
Buurt 5 Zuid	22285	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	176
Buurt 5 Zuid	22285_	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	173
Buurt 5 Zuid	22285__	Residential	Semi- detached house	Owner Occupied		2	1955	2	Flat	166
Buurt 5 Zuid	15354	Residential	Rowhouses	Social Rental	Eigen haard	7	1954	3	Open Gable	326
Buurt 5 Zuid	15821	Residential	Rowhouses	Social Rental	Eigen haard	20	1954	3	Open Gable	967
Buurt 5 Zuid	15203	Residential	Rowhouses	Social Rental	Eigen haard	7	1954	3	Open Gable	327
Buurt 5 Zuid	16038	Residential	Rowhouses	Social Rental	Eigen haard	20	1954	3	Open Gable	915
Buurt 5 Zuid	15324	Residential	Rowhouses	Social Rental	Eigen haard	9	1954	3	Open Gable	288
Buurt 5 Zuid	15400	Residential	Rowhouses	Social Rental	Eigen haard	20	1954	3	Open Gable	1035
Buurt 5 Zuid	22289	Residential	Rowhouses	Owner Occupied		4	1954	2	Flat	241
Buurt 5 Zuid	22289_	Residential	Rowhouses	Owner Occupied		4	1955	2	Flat	310
Buurt 5 Zuid	22290	Residential	Rowhouses	Owner Occupied		4	1955	2	Flat	299
Buurt 5 Zuid	22290_	Residential	Rowhouses	Owner Occupied		4	1955	2	Flat	284
Buurt 5 Zuid	22291	Residential	Rowhouses	Owner Occupied		4	1955	2	Flat	294
Buurt 5 Zuid	22291_	Residential	Rowhouses	Owner Occupied		4	1955	2	Flat	386
Buurt 5 Zuid	15250	Residential	Rowhouses	Social Rental	Eigen haard	9	1954	3	Open Gable	367
Buurt 5 Zuid	16267	Residential	Rowhouses	Social Rental	Eigen haard	8	1954	3	Open Gable	322
Buurt 5 Zuid	15232	Residential	Rowhouses	Social Rental	Eigen haard	8	1954	3	Open Gable	346
Buurt 5 Zuid	15267	Residential	Rowhouses	Social Rental	Eigen haard	7	1954	3	Open Gable	329
Buurt 5 Zuid	15926	Residential	Rowhouses	Social Rental	Eigen haard	8	1954	3	Open Gable	323
Buurt 5 Zuid	15252	Residential	Rowhouses	Social Rental	Eigen haard	8	1954	3	Open Gable	310
Buurt 5 Zuid	22286	Residential	Rowhouses	Owner Occupied		4	1954	2	Flat	327
Buurt 5 Zuid	22286_	Residential	Rowhouses	Owner Occupied		4	1954	2	Flat	327
Buurt 5 Zuid	22287	Residential	Rowhouses	Owner Occupied		4	1954	2	Flat	327
Buurt 5 Zuid	22287_	Residential	Rowhouses	Owner Occupied		4	1954	2	Flat	327
Buurt 5 Zuid	22288	Residential	Rowhouses	Owner Occupied		4	1954	2	Flat	327
Buurt 5 Zuid	22288_	Residential	Rowhouses	Owner Occupied		4	1954	2	Flat	327
Buurt 5 Zuid	22288__	Residential	Rowhouses	Owner Occupied		4	1954	2	Flat	312
Buurt 5 Zuid	22953	Education	Other			1	1955	3	Open Gable	2241
Slotermeer Zuid	23094	Offices	Other			1	1964			1000
Slotermeer Zuid	23018	Hotel	Other			1	1981			2815
Slotermeer Zuid	17948	Residential	Multifamily house	Social Rental	Rochdale	21	1992	6	Flat	344
Slotermeer Zuid	18948	Residential	Multifamily house	Social Rental	Rochdale	23	1998	6	Flat	344
Slotermeer Zuid	18919	Residential	Multifamily house	Owner Occupied		23	1998	6	Flat	344
Slotermeer Zuid	18920	Residential	Multifamily house	Owner Occupied		23	1998	6	Flat	344
Slotermeer Zuid	22295	Residential	Detached house	Owner Occupied		1	1956	2	Flat	160
Slotermeer Zuid	18069	Residential	Multifamily house	Social Rental	Stadgenoot	8	1954	2	Open Gable	226
Slotermeer Zuid	18073	Residential	Multifamily house	Social Rental	Stadgenoot	10	1954	2	Open Gable	271
Slotermeer Zuid	18669	Residential	Multifamily house	Social Rental	Stadgenoot	20	1954	2	Open Gable	572
Slotermeer Zuid	12971	Residential	Multifamily house	Social Rental	Stadgenoot	16	1954	2	Open Gable	499
Slotermeer Zuid	18904	Residential	Multifamily house	Social Rental	Stadgenoot	35	1954	2	Open Gable	1130
Slotermeer Zuid	18627	Residential	Multifamily house	Social Rental	Stadgenoot	18	1954	2	Open Gable	501
Slotermeer Zuid	23053	Education	Other			1	1965			1366
Slotermeer Zuid	19116	Residential	Rowhouses	Social Rental	Stadgenoot	36	1953	2	Open Gable	1666
Slotermeer Zuid	16677	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1953	3	Open Gable	391
Slotermeer Zuid	18843	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	91	1953	4	Open Gable	2384
Slotermeer Zuid	22295_	Residential	Detached house	Owner Occupied		1	1956	2	Flat	128
Slotermeer Zuid	18039	Residential	Multifamily house	Social Rental	Stadgenoot	10	1954	2	Open Gable	295
Slotermeer Zuid	18629	Residential	Multifamily house	Social Rental	Stadgenoot	18	1954	2	Open Gable	558
Slotermeer Zuid	18905	Residential	Multifamily house	Social Rental	Stadgenoot	35	1954	2	Open Gable	1120
Slotermeer Zuid	18129	Residential	Multifamily house	Social Rental	Stadgenoot	16	1954	2	Open Gable	461
Slotermeer Zuid	18686	Residential	Multifamily house	Social Rental	Stadgenoot	34	1954	2	Open Gable	1011
Slotermeer Zuid	19372	Residential	Multifamily house	Social Rental	Stadgenoot	34	1954	2	Open Gable	1070
Slotermeer Zuid	18592	Residential	Multifamily house	Social Rental	Stadgenoot	18	1954	2	Open Gable	566
Slotermeer Zuid	15689	Residential	Multifamily house	Social Rental	Stadgenoot	36	1953	2	Open Gable	1044
Slotermeer Zuid	16091	Residential	Rowhouses	Social Rental	Stadgenoot	17	1953	2	Open Gable	717
Slotermeer Zuid	15603	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1953	3	Open Gable	391
Slotermeer Zuid	15838	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1953	3	Open Gable	391
Slotermeer Zuid	18781	Residential	Rowhouses	Social Rental	Eigen haard	17	1954	2	Open Gable	1089
Slotermeer Zuid	18782	Residential	Rowhouses	Social Rental	Eigen haard	17	1954	2	Open Gable	1089
Slotermeer Zuid	18780	Residential	Rowhouses	Social Rental	Eigen haard	17	1954	2	Open Gable	1089
Slotermeer Zuid	22295__	Residential	Detached house	Owner Occupied		1	1956	2	Flat	127
Slotermeer Zuid	18105	Residential	Multifamily house	Social Rental	Stadgenoot	8	1954	2	sloped	241
Slotermeer Zuid	18358	Residential	Rowhouses	Social Rental	Eigen haard	7	1954	2	Open Gable	337
Slotermeer Zuid	18356	Residential	Rowhouses	Social Rental	Eigen haard	7	1954	2	Open Gable	337
Slotermeer Zuid	18357	Residential	Rowhouses	Social Rental	Eigen haard	7	1954	2	Open Gable	337
Slotermeer Zuid	22295___	Residential	Detached house	Owner Occupied		1	1959	2	Flat	103
Slotermeer Zuid	8572	Residential	Multifamily house	Social Rental	Stadgenoot	11	1957	2	Open Gable	573
Slotermeer Zuid	18767	Res & Off	Other			13	1957	2	Open Gable	650
Slotermeer Zuid	19124	Residential	Multifamily house	Social Rental	Stadgenoot	16	1953	2	Flat	516
Slotermeer Zuid	23511	Education	Other			1	1956			520
Slotermeer Zuid	22295____	Residential	Detached house	Owner Occupied		1	1958	2	Flat	71

Electricity consumption kWh	Use surface m2	kWh/m2	Gas consumption m3	Use surface m2	Consumption average per m2	Heating Energy kWh/m2	Gas CO2 emmisions m3	CO2 emission per dwelling
7241.5	195	37.1	4248	195	21.8	212.8	7561	3780.72
7241.5	195	37.1	4248	195	21.8	212.8	7561	3780.72
140714	2202	63.9	29638	2202	13.5	131.5	52756	4795.967273
32760	1106	29.6	17360	1106	15.7	153.3	30901	2575.066667
224484	5642	39.8		5642		39.8	136486	2624.736
69600	1872	37.2	35280	1872	18.8	184.1	62798	2854.472727
67320	2128	31.6	44576	2128	20.9	204.6	79345	2479.54
69972	1853	37.8	34074	1853	18.4	179.6	60652	2166.132857
13702.5	334.5	41.0	7659	334.5	22.9	223.7	13633	6816.51
13702.5	334.5	41.0	7659	334.5	22.9	223.7	13633	6816.51
7615	174	43.8	4738	174	27.2	266.0	8434	4216.82
7615	174	43.8	4738	174	27.2	266.0	8434	4216.82
492		#DIV/0!			-	-	-	-
492		#DIV/0!			-	-	-	-
30168	1034	29.2	18640	1034	18.0	176.1	33179	2211.946667
39995	1020	39.2	21296	1020	20.9	204.0	37907	3158.906667
40520	1017	39.8	21728	1017	21.4	208.7	38676	2762.56
99936	3945	25.3	44720	3945	11.3	110.7	79602	4975.1
88648	1755	50.5	33384	1755	19.0	185.8	59424	2285.52
50004	1774	28.2	33384	1774	18.8	183.8	59424	2285.52
45034	1511	29.8	24266	1511	16.1	156.9	43193	1963.34
13702.5	334.5	41.0	9294	334.5	27.8	271.4	16543	8271.66
13032	285	45.7	9294	334.5	27.8	271.4	16543	8271.66
13032	285	45.7	10992	285	38.6	376.8	19566	9782.88
7615	174	43.8	4738	174	27.2	266.0	8434	4216.82
8391	174	48.2	3442	174	19.8	193.2	6127	3063.38
8391	174	48.2	3442	174	19.8	193.2	6127	3063.38
8391	174	48.2	3442	174	19.8	193.2	6127	3063.38
16896	432	39.1	8904	432	20.6	201.3	15849	2264.16
38399	1237	31.0	19665	1237	15.9	155.3	35004	1750.185
13304	416	32.0	8784	416	21.1	206.3	15636	2233.645714
32940	1287	25.6	19940	1287	15.5	151.4	35493	1774.66
12400	429	28.9	8248	429	19.2	187.8	14681	1631.271111
41680	1254	33.2	23780	1254	19.0	185.3	42328	2116.42
10620	324	32.8	6100	324	18.8	183.9	10858	2714.5
11207	324	34.6	6100	324	18.8	183.9	10858	2714.5
15012	324	46.3	9296	324	28.7	280.3	16547	4136.72
15520	324	47.9	9296	324	28.7	280.3	16547	4136.72
19140	324	59.1	8240	324	25.4	248.4	14667	3666.8
16800	324	51.9	8240	324	25.4	248.4	14667	3666.8
22088	416	53.1	9376	416	22.5	220.2	16689	1854.364444
13304	416	32.0	7816	429	18.2	178.0	13912	1739.06
12400	429	28.9	6768	444	15.2	148.9	12047	1505.88
22088	416	53.1	9944	416	23.9	233.5	17700	2528.617143
10728	416	25.8	7280	416	17.5	171.0	12958	1619.8
13088	416	31.5	7288	378	19.3	188.4	12973	1621.58
9760	378	25.8	7720	378	20.4	199.5	13742	3435.4
8190	324	25.3	7720	324	23.8	232.8	13742	3435.4
9864	324	30.4	7176	324	22.1	216.4	12773	3193.32
9300	324	28.7	7176	324	22.1	216.4	12773	3193.32
11545	324	35.6	6292	324	19.4	189.7	11200	2799.94
8687	324	26.8	6292	324	19.4	189.7	11200	2799.94
10962	370	29.6	6292	370	17.0	166.1	11200	2799.94
1034180	15421	67.1	142255	15421	-	-	-	-
					-	-	-	-
					-	-	-	-
38682	1225	31.6	16443	1225	13.4	131.1	29269	1393.74
37691.1	1731	21.8	21666	1731	12.5	122.3	38565	1676.76
47336.4	1999	23.7	22563	1999	11.3	110.3	40162	1746.18
35414.8	2007	17.6	22333	2007	11.1	108.7	39753	1728.38
6587	169.2	38.9	3544.8	169.2	21.0	204.7	6310	6309.744
10350	328	31.6	6672	328	20.3	198.7	11876	1484.52
11176	410	27.3	7310	410	17.8	174.2	13012	1301.18
32970	820	40.2	15200	820	18.5	181.1	27056	1352.8
22508	656	34.3	13072	656	19.9	194.7	23268	1454.26
44496	1488	29.9	31290	1488	21.0	205.4	55696	1591.32
25612	738	34.7	14418	738	19.5	190.9	25664	1425.78
					-	-	-	-
85608	2258	37.9	44484	2258	19.7	192.5	79182	2199.486667
40413	972	41.6	16920	972	17.4	170.1	30118	1673.2
351594	6661	52.8	130221	6661	19.5	191.0	231793	2547.18
6587	169.2	38.9	3544.8	169.2	21.0	204.7	6310	6309.744
14421	410	35.2	9930	410	24.2	236.6	17675	1767.54
22743	738	30.8	15804	738	21.4	209.2	28131	1562.84
54504	1483	36.8	32095	1483	21.6	211.4	57129	1632.26
21165	656	32.3	10208	656	15.6	152.0	18170	1135.64
44520	1419	31.4	25330	1419	17.9	174.4	45087	1326.1
56420	1402	40.2	31790	1402	22.7	221.5	56586	1664.3
18772	738	25.4	12996	738	17.6	172.0	23133	1285.16
52947	1472	36.0	26964	1472	18.3	178.9	47996	1333.22
43328	1125	38.5	17790	1125	15.8	154.5	31666	1862.717647
35435	972	36.5	19170	972	19.7	192.7	34123	1895.7
46588	972	47.9	21600	972	22.2	217.1	38448	2136
70856	1317	53.8	32164	1317	24.4	238.6	57252	3367.76
50540	1286	39.3	21182	1286	16.5	160.9	37704	2217.88
50456	1278	39.5	21318	1278	16.7	163.0	37946	2232.12
6587	169.2	38.9	3544.8	169.2	21.0	204.7	6310	6309.744
63570	328	193.8	8680	328	26.5	258.5	15450	1931.3
14434	483	29.9	10836	483	22.4	219.2	19288	2755.44
20048	483	41.5	11438	483	23.7	231.3	20360	2908.52
12610	483	26.1	10751	483	22.3	217.4	19137	2733.825714
6587	169.2	38.9	3544.8	169.2	21.0	204.7	6310	6309.744
38520	861	44.7	21504	861	25.0	244.0	38277	3479.738182
44380	1157	38.4	18368	1157	-	-	-	-
23085	837	27.6	18486	837	22.1	215.8	32905	2056.5675
					-	-	-	-
?	846	#VALUE!	17724	846	21.0	204.7	31549	31548.72

Neighbourhood	Block number	Function	House typology	Stakeholder	S. classification	No. of Dwellings	Year of construction	Storeys number	Type of roof	Footprint m2
Slotermeer Zuid	23053	Education	Other			1	1957			2051
Slotermeer Zuid	15765	Residential	Rowhouses	Social Rental	Stadgenoot	18	1953	2	Open Gable	727
Slotermeer Zuid	15395	Res & Off	Rowhouses	Social Rental	Stadgenoot	18	1953	2	Open Gable	732
Slotermeer Zuid	15882	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1953	3	Open Gable	391
Slotermeer Zuid	18148	Residential	Rowhouses	Social Rental	Eigen haard	8	1954	2	Open Gable	419
Slotermeer Zuid	18149	Residential	Rowhouses	Social Rental	Eigen haard	8	1954	2	Open Gable	419
Slotermeer Zuid	18147	Residential	Rowhouses	Social Rental	Eigen haard	8	1954	2	Open Gable	419
Slotermeer Zuid	22295____	Residential	Detached house	Owner Occupied		1	1958	2	Flat	201
Slotermeer Zuid	13181	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	2	Open Gable	639
Slotermeer Zuid	15858	Residential	Rowhouses	Social Rental	Stadgenoot	7	1957	2	Open Gable	523
Slotermeer Zuid	15594	Residential	Rowhouses	Social Rental	Stadgenoot	8	1953	3	Open Gable	356
Slotermeer Zuid	15654	Residential	Rowhouses	Social Rental	Stadgenoot	8	1953	3	Open Gable	333
Slotermeer Zuid	15993	Residential	Rowhouses	Social Rental	Stadgenoot	8	1953	3	Open Gable	371
Slotermeer Zuid	15415	Residential	Rowhouses	Social Rental	Stadgenoot	8	1953	3	Open Gable	326
Slotermeer Zuid	15533	Residential	Rowhouses	Social Rental	Stadgenoot	8	1953	3	Open Gable	330
Slotermeer Zuid	15205	Residential	Rowhouses	Social Rental	Stadgenoot	8	1953	3	Open Gable	300
Slotermeer Zuid	15994	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1953	3	Open Gable	391
Slotermeer Zuid	15836	Residential	Apartment blocks Portiekflat	Social Rental	Ymere	18	1953	3	Open Gable	391
Slotermeer Zuid	18747	Residential	Multifamily house	Social Rental	Eigen haard	34	1954	2	Open Gable	1118
Slotermeer Zuid	13179	Residential	Multifamily house	Social Rental	Eigen haard	34	1954	2	Open Gable	1099
Slotermeer Zuid	19371	Residential	Multifamily house	Social Rental	Eigen haard	34	1954	2	Open Gable	1138
Slotermeer Zuid	23511	School	Other			1	1964			1632
Slotermeer Zuid	23508	School	Other			1	1964			746
Slotermeer Zuid	16517	Residential	Multifamily house	Social Rental	Stadgenoot	20	1954	2	Open Gable	898
Slotermeer Zuid	16537	Residential	Multifamily house	Social Rental	Stadgenoot	20	1954	2	Open Gable	903
Slotermeer Zuid	15820	Residential	Multifamily house	Social Rental	Stadgenoot	18	1953	2	Flat	602
Slotermeer Zuid	15863	Residential	Multifamily house	Social Rental	Stadgenoot	14	1953	2	Open Gable	620
Slotermeer Zuid	15525	Res & Off	Multifamily house	Social Rental	Stadgenoot	20	1953	2	Open Gable	882
Slotermeer Zuid	16428	Res & Off	Apartment blocks Portiekflat	Social Rental	Stadgenoot	72	1954	5	Flat	1151
Slotermeer Zuid	16640	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	72	1953	5	Flat	1151
Slotermeer Zuid	16212	Residential	Apartment blocks Gallerijflat	Social Rental	Stadgenoot	46	1958	5	Flat	859
Slotermeer Zuid	16621	Residential	Apartment blocks Gallerijflat	Owner Occupied		78	1958	8	Flat	853
Slotermeer Zuid	15979	Residential	Rowhouses	Owner Occupied		10	1958	2	Flat	606
Slotermeer Zuid	12819	Residential	Rowhouses	Social Rental	Eigen haard	16	1954	2	Open Gable	506
Slotermeer Zuid	19366	Residential	Rowhouses	Social Rental	Eigen haard	16	1954	2	Open Gable	423
Slotermeer Zuid	16214	Residential	Rowhouses	Social Rental	Eigen haard	16	1954	2	Open Gable	369
Slotermeer Zuid	16563	Residential	Multifamily house	Social Rental	Stadgenoot	20	1954	2	Open Gable	831
Slotermeer Zuid	16483	Residential	Multifamily house	Social Rental	Stadgenoot	20	1954	2	Open Gable	902
Slotermeer Zuid	15420	Residential	Multifamily house	Social Rental	Stadgenoot	8	1953	2	Open Gable	353
Slotermeer Zuid	15781	Residential	Multifamily house	Social Rental	Stadgenoot	12	1953	2	Open Gable	456
Slotermeer Zuid	3390	Residential	Multifamily house	Social Rental	Stadgenoot	36	1953	2	Open Gable	857
Slotermeer Zuid	16295	:ducation & Care	Other			1	1962			1195
Slotermeer Zuid	15534	Residential	Rowhouses	Social Rental	Eigen haard	16	1954	2	Open Gable	354
Slotermeer Zuid	15595	Residential	Rowhouses	Social Rental	Eigen haard	16	1954	2	Open Gable	357
Slotermeer Zuid	15658	Residential	Rowhouses	Social Rental	Eigen haard	16	1954	2	Open Gable	352
Slotermeer Zuid	16274	Residential	Rowhouses	Social Rental	Stadgenoot	8	1953	2	Open Gable	381
Slotermeer Zuid	16255	Residential	Multifamily house	Social Rental	Stadgenoot	20	1953	2	Open Gable	540
Slotermeer Zuid	16387	Residential	Multifamily house	Social Rental	Eigen haard	40	1954	2	Shed	1377
Slotermeer Zuid	22657	Church	Other				1967			644
Slotermeer Zuid	22960	Office	Other			1	1956	2	Flat	197
Noordoever Sloterplas	16507	Residential	Multifamily house	Owner Occupied		120	1998	4	Flat	9601
Noordoever Sloterplas	16486	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	72	1955	5	Hip	1208
Noordoever Sloterplas	16545	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	72	1955	5	Hip	1223
Noordoever Sloterplas	16544	& educ. & reast.	Apartment blocks Portiekflat	Social Rental	Stadgenoot	72	1956	5	Hip	1259
Noordoever Sloterplas	23498	Residential	Apartment blocks Gallerijflat	Owner Occupied	Ymere	150	1965	15	Flat	1508
Noordoever Sloterplas	23005	Education	Other			1	1969			7655
Noordoever Sloterplas	16478	Residential	Apartment blocks Gallerijflat	Owner Occupied		80	1957	8	Flat	1132
Noordoever Sloterplas	16439	Residential	Multifamily house	Social Rental	Alliantie	207	1986	4	Flat	4329
Noordoever Sloterplas	16285	Residential	Rowhouses	Owner Occupied		23	1986	2	Flat	1233
Noordoever Sloterplas	22657	Church	Other			1	1957			1306
Noordoever Sloterplas	15452	Residential	Rowhouses	Owner Occupied		11	1998	2	Flat	680
Noordoever Sloterplas	15471	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	20	1955	5	Hip	332
Noordoever Sloterplas	15927	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	20	1955	5	Hip	356
Noordoever Sloterplas	16050	Residential	Apartment blocks Portiekflat	Social Rental	Stadgenoot	20	1956	5	Hip	349
Noordoever Sloterplas	22292	Residential	Rowhouses	Owner Occupied		6	1998	2	Flat	260
Noordoever Sloterplas	16468	Residential	Apartment blocks Gallerijflat	Owner Occupied		150	1965	15	Flat	1508
Noordoever Sloterplas	16495	Residential	Apartment blocks Gallerijflat	Owner Occupied		150	1965	15	Flat	1508
Noordoever Sloterplas	16457	Residential	Multifamily house	Social Rental	Ymere	70	1986	5	Flat	1113
Noordoever Sloterplas	16037	Residential	Rowhouses	Owner Occupied		11	1998	2	Flat	702
Noordoever Sloterplas	16143	Residential	Rowhouses	Owner Occupied		11	1998	2	Flat	803
Noordoever Sloterplas	21662	Restaurant	Other			1	2013			184
Buurt 3	18719		Apartment blocks Portiekflat	Owner Occupied		56	1958	5	Flat	1149
Buurt 3	18943		Apartment blocks Portiekflat	Owner Occupied		56	1958	5	Flat	1049
Buurt 3	18830		Semi- detached house	Owner Occupied		2	1954	2	Open Gable	625
Buurt 3	18606		Rowhouses	Social Rental	Alliantie	32	1953	2	Open Gable	819
Buurt 3	18609		Rowhouses	Social Rental	Alliantie	32	1953	2	Open Gable	769
Buurt 3	18608		Rowhouses	Social Rental	Alliantie	32	1953	2	Open Gable	784
Buurt 3	18607		Rowhouses	Social Rental	Alliantie	32	1953	2	Open Gable	805
Buurt 3	18831		Rowhouses	Owner Occupied		19	1954	2	Flat	972
Buurt 3	18812		Rowhouses	Owner Occupied		19	1954	2	Flat	958
Buurt 3	18811		Rowhouses	Owner Occupied		19	1954	2	Flat	917
Buurt 3	18930		Rowhouses	Owner Occupied		19	1954	2	Flat	818
Buurt 3	18447		Rowhouses	Owner Occupied		7	1953	2	Flat	341
Buurt 3	18692		Apartment blocks Portiekflat	Unknown		64	1954	5	Flat	1424
Buurt 3	18321		Apartment blocks Portiekflat	Owner Occupied		24	1955	5	Flat	452
Buurt 3	18320		Apartment blocks Portiekflat	Owner Occupied		24	1955	5	Flat	431
Buurt 3	18323		Apartment blocks Portiekflat	Owner Occupied		24	1955	5	Flat	470
Buurt 3	18322		Apartment blocks Portiekflat	Owner Occupied		24	1955	5	Flat	435
Buurt 3	18964		Apartment blocks Portiekflat	Owner Occupied		126	1958	9	Flat	723
Buurt 3	23499	Kindergarden	Other				1960			1018
Buurt 3	18895		Rowhouses	Social Rental	Alliantie	14	1953	2	Open Gable	754
Buurt 3	18897		Rowhouses	Social Rental	Alliantie	14	1953	2	Open Gable	775
Buurt 3	18896		Rowhouses	Social Rental	Alliantie	14	1953	2	Open Gable	726
Buurt 3	18894		Rowhouses	Social Rental	Alliantie	14	1953	2	Open Gable	761
Buurt 3	22657	Monastary	Other				1955			1373
Buurt 3	23499	Church	Other				1957			724
Buurt 3	18988		Rowhouses	Owner Occupied		19	1954	2	Flat	866

Electricity consumption kWh	Use surface m2	kWh/m2	Gas consumption m3	Use surface m2	Consumption average per m2	Heating Energy kWh/m2	Gas CO2 emmisions m3	CO2 emission per dwelling
					-	-	-	-
41616	1065	39.1	16192	1065	15.2	148.5	28822	1601.208889
40245	1110	36.3	25648	1110	23.1	225.7	45653	2536.302222
31597	972	32.5	19674	972	20.2	197.7	35020	1945.54
30480	552	55.2	11472	552	20.8	203.0	20420	2552.52
19120	552	34.6	12112	552	21.9	214.4	21559	2694.92
29312	552	53.1	14336	552	26.0	253.7	25518	3189.76
6587	169.2	38.9	3544.8	169.2	21.0	204.7	6310	6309.744
15330	612	25.0	11928	612	19.5	190.4	21232	3033.12
13104	612	21.4	11435	612	18.7	182.5	20354	2907.757143
27568	541	51.0	11976	541	22.1	216.3	21317	2664.66
16696	541	30.9	11440	541	21.1	206.6	20363	2545.4
31216	541	#REF!	12280	541	22.7	221.7	21858	2732.3
14400	541	26.6	9919	541	18.3	179.1	17656	2206.9775
20592	541	38.1	11912	541	22.0	215.1	21203	2650.42
18216	541	33.7	13496	541	24.9	243.7	24023	3002.86
39957	972	41.1	19728	972	20.3	198.3	35116	1950.88
33877	972	34.9	20340	972	20.9	204.4	36205	2011.4
34848	1356	25.7	23360	1356	17.2	168.3	41581	1222.964706
46376	1281	36.2	35802	1281	27.9	273.0	63728	1874.34
62650	1261	49.7	29925	1261	23.7	231.8	53267	1566.661765
					-	-	-	-
					-	-	-	-
76738	1519	50.5	34891	1519	23.0	224.4	62106	3105.299
51084	1511	33.8	26530	1511	17.6	171.5	47223	2361.17
33022	954	#REF!	18460	954	19.4	189.0	32859	1825.488889
48074	1121	42.9	22350	1121	19.9	194.8	39783	2841.642857
47268	1555	30.4	28440	1555	18.3	178.7	50623	2531.16
183225	4667	39.3	77328	4667	16.6	161.9	137644	1911.72
229400	4685	49.0	82008	4685	17.5	171.0	145974	2027.42
144912	2471	58.6	62744	2471	25.4	248.1	111684	2427.92
224289	5639	39.8	20826	5639	3.7	36.1	37070	475.26
37600	1030	36.5	23420	1030	22.7	222.1	41688	4168.76
30224	552	54.8	11360	552	20.6	201.0	20221	1263.8
20816	552	37.7	12320	552	22.3	218.0	21930	1370.6
16112	552	29.2	12624	552	22.9	223.4	22471	1404.42
55278	1483	37.3	29592	1483	20.0	194.9	52674	2633.688
69303	1559	44.5	35036	1559	22.5	219.5	62364	3118.204
32184	574	56.1	15392	574	26.8	262.0	27398	3424.72
28224	738	38.2	19404	738	26.3	256.9	34539	2878.26
54990	1564	35.2	31692	1564	20.3	198.0	56412	1566.993333
					-	-	-	-
33120	552	60.0	11920	552	21.6	211.0	21218	1326.1
18736	552	33.9	9696	552	17.6	171.6	17259	1078.68
22848	552	41.4	10880	552	19.7	192.5	19366	1210.4
28496	618	46.1	15105	618	24.4	238.8	26887	3360.8625
37152	943	39.4	14789	943	15.7	153.2	26324	1316.221
53148	1563	34.0	39774	1563	25.4	248.6	70798	1769.943
					-	-	-	-
					-	-	-	-
462220	13201	35.0	156840	13201	11.9	116.1	279175	2326.46
152440	4284	35.6	94032	4284	21.9	214.4	167377	2324.68
148074	4212	35.2	96624	4212	22.9	224.1	171991	2388.76
189720	4046	46.9	89610	4046	22.1	216.4	159506	2215.358333
492371	12712	38.7	56092	12712	4.4	43.1	99844	665.6250667
1211427		#DIV/0!	789285		-	-	-	-
284200	5934	47.9	153052	6462	23.7	231.4	272433	3405.407
539540	15593	34.6	218178	15593	14.0	136.7	388357	1876.12
93311	2583	36.1	32039	2583	12.4	121.2	57029	2479.54
					-	-	-	-
44033	1291	34.1	15092	1291	11.7	114.2	26864	2442.16
39564	1218	32.5	31160	1218	25.6	249.9	55465	2773.24
44814	1201	37.3	27860	1201	23.2	226.6	49591	2479.54
45759	1198	38.2	27940	1198	23.3	227.8	49733	2486.66
12600	600	21.0	10992	600	18.3	179.0	19566	3260.96
496881	12825	38.7	16485	12825	1.3	12.6	29343	195.622
508032	12703	40.0	49896	12703	3.9	38.4	88815	592.0992
21660	4625	4.7	71262	4625	15.4	150.5	126846	1812.090857
45001	1278	35.2	16720	1278	13.1	127.8	29762	2705.6
43659	1268	34.4	14938	1268	11.8	115.1	26590	2417.24
								#VALUE!
39104	3444	11.4	18132	3444	5.264808362	51.4	32275	576.3385714
57239	3241	17.7	34293	3241	10.58099352	103.4	61042	1090.0275
30704	717	42.8	21376	717	29.81311018	291.2	38049	19024.64
70125	1246	56.3	18432	1246	14.7929374	144.5	32809	1025.28
72284	1262	57.3	27744	1262	21.98415214	214.8	49384	1543.26
76824	1232	62.4	23584	1232	19.14285714	187.0	41980	1311.86
88900	1232	72.2	22847	1232	18.54464286	181.2	40668	1270.864375
60900	1616	37.7	29120	1616	18.01980198	176.0	51834	2728.084211
60900	1616	37.7	29120	1616	18.01980198	176.0	51834	2728.084211
60900	1616	37.7	29120	1616	18.01980198	176.0	51834	2728.084211
55278	1262	43.8	29682	1262	23.51980983	229.8	52834	2780.734737
18641	636	29.3	10577	697	15.17503587	148.2	18827	2689.58
161841	4098	39.5	84800	4546	18.65376155	182.2	150944	2358.5
59050	1605	36.8	36000	1605	22.42990654	219.1	64080	2670
61375	1599	38.4	31104	1599	19.4521576	190.0	55365	2306.88
57225	1599	35.8	30960	1599	19.36210131	189.1	55109	2296.2
56875	1596	35.6	37656	1596	23.59398496	230.5	67028	2792.82
301620	4666	64.6	98280	4666	21.063009	205.8	174938	1388.4
					-	-	-	-
70180	1192	58.9	17255	1192	14.47567114	141.4	30714	2193.85
83328	1163	71.6	16240	1163	13.9638865	136.4	28907	2064.8
66015	1163	56.8	16335	1163	14.0455718	137.2	29076	2076.878571
87725	1181	74.3	20271	1181	17.16426757	167.7	36082	2577.312857
					-	-	-	-
					-	-	-	-
57038	1422	40.1	28500	1492	19.10187668	186.6	50730	2670

Neighbourhood	Block number	Function	House typology	Stakeholder	S. classification	No. of Dwellings	Year of construction	Storeys number	Type of roof	Footprint m2
Buurt 3	18987		Rowhouses	Owner Occupied		19	1954	2	Flat	857
Buurt 3	18989		Rowhouses	Owner Occupied		19	1954	2	Flat	841
Buurt 3	18857		Rowhouses	Owner Occupied		16	1954	2	Flat	748
Buurt 3	18448		Rowhouses	Owner Occupied		7	1953	2	Flat	341
Buurt 3	18446		Rowhouses	Owner Occupied		7	1953	2	Flat	304
Buurt 3	22455		Semi- detached house	Private Rental		2	1954	2	Flat	164
Buurt 3	18280		Rowhouses	Owner Occupied		9	1954	2	Flat	414
Buurt 3	18927		Rowhouses	Owner Occupied		14	1954	2	Flat	688
Buurt 3	22455_		Semi- detached house	Owner Occupied		2	1954	2	Flat	98
Buurt 3	18745		Rowhouses	Owner Occupied		19	1954	2	Flat	819
Buurt 3	22455__		Semi- detached house	Owner Occupied		2	1954	2	Flat	93
Buurt 3	18832		Rowhouses	Owner Occupied		19	1953	2	Flat	958
Buurt 3	18084		Rowhouses	Owner Occupied		9	1953	2	Flat	425
Buurt 3	19071		Apartment blocks Portiekflat	Social Rental	Eigen haard	96	1954	5	Flat	2494
Buurt 3	18883		Apartment blocks Portiekflat	Social Rental	Alliantie	32	1954	5	Open Gable	777
Buurt 3	18597		Apartment blocks Portiekflat	Social Rental	Alliantie	32	1954	5	Open Gable	608
Buurt 3	18957		Apartment blocks Portiekflat	Social Rental	Alliantie	40	1954	5	Open Gable	852
Buurt 3	22960	Office	Other				1956			733
Buurt 3	18552		Rowhouses	Social Rental	Alliantie	5	1953	1	Flat	215
Buurt 3	18408		Rowhouses	Social Rental	Alliantie	13	1953	2	Open Gable	403
Buurt 3	18549		Rowhouses	Social Rental	Alliantie	5	1953	2	Open Gable	197
Buurt 3	18595		Rowhouses	Social Rental	Alliantie	13	1953	2	Open Gable	387
Buurt 3	18551		Rowhouses	Social Rental	Alliantie	5	1953	2	Open Gable	209
Buurt 3	16693		Rowhouses	Social Rental	Alliantie	13	1953	2	Open Gable	402
Buurt 3	18550		Rowhouses	Social Rental	Alliantie	5	1953	2	Open Gable	227
Buurt 3	16694		Rowhouses	Social Rental	Alliantie	13	1953	2	Open Gable	393
Buurt 3	18670		Rowhouses	Owner Occupied		19	1954	2	Flat	536
Buurt 3	18672		Rowhouses	Owner Occupied		10	1954	2	Flat	539
Buurt 3	18671		Rowhouses	Owner Occupied		10	1954	2	Flat	542
Buurt 3	23016	Church	Other				1985			839
Buurt 3	22455___		Semi- detached house	Owner Occupied		2	1954	2	Flat	193
Buurt 3	18553		Rowhouses	Owner Occupied		5	1954	2	Flat	231
Buurt 3	18071		Rowhouses	Owner Occupied		6	1954	2	Flat	239
Buurt 3	22454		Semi- detached house	Owner Occupied		2	1955	2	Flat	143
Buurt 3	22454_		Semi- detached house	Owner Occupied		2	1957	2	Flat	183
Buurt 3	22454__		Detached house	Owner Occupied		1	1956	2	Flat	148
Buurt 3	23093		Other			3	1955	2	Flat	360
Buurt 3	18614		Rowhouses	Owner Occupied		20	1953	2	Flat	1541
Buurt 3	18053		Rowhouses	Owner Occupied		10	1954	2	Flat	397
Buurt 3	18212		Rowhouses	Owner Occupied		10	1953	2	Flat	367
Buurt 3	18768		Multifamily house	Owner Occupied		10	1955	3	Flat	718
Buurt 3	18562		Rowhouses	Owner Occupied		7	1953	2	Flat	299
Buurt 3	18884		Apartment blocks Portiekflat	Social Rental	Alliantie	32	1955	5	Open Gable	544
Buurt 3	18881		Apartment blocks Portiekflat	Social Rental	Alliantie	32	1954	5	Open Gable	547
Buurt 3	18982		Apartment blocks Portiekflat	Social Rental	Alliantie	40	1954	5	Open Gable	762
Buurt 3	18866		Apartment blocks Portiekflat	Social Rental	Alliantie	34	1954	5	Open Gable	1090
Buurt 3	17967		Rowhouses	Owner Occupied		8	1955	2	Open Gable	326
Buurt 3	19052		Rowhouses	Owner Occupied		14	1955	3	Open Gable	678
Buurt 3	18002		Rowhouses	Owner Occupied		8	1955	2	Open Gable	326
Buurt 3	18921		Rowhouses	Owner Occupied		14	1955	2	Open Gable	652
Buurt 3	18497		Rowhouses	Owner Occupied		8	1955	2	Open Gable	322
Buurt 3	18885		Rowhouses	Owner Occupied		14	1955	2	Open Gable	641
Buurt 3	18526		Rowhouses	Owner Occupied		5	1953	2	Flat	240
Buurt 3	18371		Rowhouses	Owner Occupied		5	1953	2	Flat	261
Buurt 3	18501		Rowhouses	Owner Occupied		6	1953	2	Flat	331
Buurt 3	18372		Rowhouses	Owner Occupied		5	1953	2	Flat	256
Buurt 3	18370		Rowhouses	Owner Occupied		5	1953	2	Flat	250
Buurt 3	18008		Rowhouses	Social Rental	Alliantie	8	1984	2	Flat	244
Buurt 3	18010		Rowhouses	Social Rental	Alliantie	8	1984	2	Flat	294
Buurt 3	18009		Rowhouses	Social Rental	Alliantie	8	1984	2	Flat	301
Buurt 3	18805		Apartment blocks Portiekflat	Social Rental	Alliantie	36	1954	5	Open Gable	803
Buurt 3	17968		Rowhouses	Owner Occupied		8	1955	2	Open Gable	355
Buurt 3	18534		Rowhouses	Owner Occupied		8	1955	2	Open Gable	343
Buurt 3	17965		Rowhouses	Owner Occupied		8	1955	2	Open Gable	345
Buurt 3	17966		Rowhouses	Owner Occupied		8	1955	2	Open Gable	387
Buurt 3	18046		Rowhouses	Owner Occupied		8	1955	2	Open Gable	362
Buurt 3	17969		Rowhouses	Owner Occupied		8	1955	2	Open Gable	356
Buurt 3	18349		Rowhouses	Social Rental	Rochdale	7	1953	3	Open Gable	304
Buurt 3	22458		Semi- detached house	Owner Occupied		2	1955	3	Flat	137
Buurt 3	22458_		Semi- detached house	Owner Occupied		2	1955	3	Flat	130
Buurt 3	22458__		Semi- detached house	Owner Occupied		2	1955	3	Flat	125
Buurt 3	22458___		Semi- detached house	Owner Occupied		2	1955	3	Flat	137
Buurt 3	22458____		Semi- detached house	Owner Occupied		2	1955	3	Flat	112
Buurt 3	22457		Semi- detached house	Owner Occupied		2	1954	3	Open Gable	210
Buurt 3	18351		Rowhouses	Social Rental	Rochdale	7	1953	3	Open Gable	335
Buurt 3	18601		Rowhouses	Social Rental	Rochdale	14	1953	2	Open Gable	707
Buurt 3	18179		Rowhouses	Social Rental	Rochdale	4	1953	2	Open Gable	243
Buurt 3	18177		Rowhouses	Social Rental	Rochdale	4	1953	2	Open Gable	202
Buurt 3	18136		Rowhouses	Social Rental	Rochdale	4	1953	2	Open Gable	203
Buurt 3	18178		Rowhouses	Social Rental	Rochdale	4	1953	2	Open Gable	243
Buurt 3	22457_		Semi- detached house	Owner Occupied		2	1954	2	Open Gable	165
Buurt 3	18350		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	345
Buurt 3	18268		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	306
Buurt 3	18204		Rowhouses	Social Rental	Rochdale	10	1953	2	Hip	515
Buurt 3	18310		Rowhouses	Social Rental	Rochdale	8	1952	3	Open Gable	298
Buurt 3	18205		Rowhouses	Social Rental	Rochdale	10	1952	2	Hip	592
Buurt 3	22457__		Semi- detached house	Owner Occupied		2	1954	2	Open Gable	121
Buurt 3	22456		Semi- detached house	Owner Occupied		2	1954	2	Open Gable	109
Buurt 3	18352		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	315
Buurt 3	18269		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	309
Buurt 3	18309		Rowhouses	Social Rental	Rochdale	8	1952	3	Open Gable	311
Buurt 3	22456_		Semi- detached house	Owner Occupied		2	1954	2	Open Gable	112
Buurt 3	22456__		Semi- detached house	Owner Occupied		2	1954	2	Open Gable	90
Buurt 3	18488		Rowhouses	Social Rental	Rochdale	8	1953	1	Flat	428
Buurt 3	18673		Rowhouses	Social Rental	Rochdale	14	1953	1	Flat	801
Buurt 3	18057		Rowhouses	Social Rental	Rochdale	10	1953	1	Flat	558
Buurt 3	18270		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	298

Electricity consumption kWh	Use surface m2	kWh/m2	Gas consumption m3	Use surface m2	Consumption average per m2	Heating Energy kWh/m2	Gas CO2 emmisions m3	CO2 emission per dwelling
63479	1492		28975	1492	19.42024129	189.7	51576	2714.5
67412	1799	37.5	28082	1799	15.60978321	152.5	49986	2630.84
39200	1257	31.2	23248	1257	18.49482896	180.7	41381	2586.34
18641	636	29.3	14252	591	24.11505922	235.6	25369	3624.08
18641	636	29.3	13433	636	21.12106918	206.3	23911	3415.82
6127	386	15.9	3820	386	9.896373057	96.7	6800	3399.8
27070	787	34.4	14346	787	18.22871665	178.1	25536	2837.32
40752	1033	39.5	24465	1033	23.68344627	231.4	43548	3110.55
5944	171	34.8	3820	186.8	20.4496788	199.8	6800	3399.8
62678	1632	38.4	27980	1714	16.3243874	159.5	49804	2621.284211
	386		3820	186.8	20.4496788	199.8	6800	3399.8
83139	1769	47.0	30744	1937	15.87196696	155.1	54724	2880.227368
29664	648	45.8	17136	648	26.44444444	258.3	30502	3389.12
221597	6713	33.0	134208	6713	19.99225384	195.3	238890	2488.44
68739	2016	34.1	37344	2016	18.52380952	181.0	66472	2077.26
91120	2036	44.8	45696	2036	22.44400786	219.3	81339	2541.84
84419	2520	33.5	53960	2520	21.41269841	209.2	96049	2401.22
					-	-	-	-
58980	1841	32.0	6030	1841	3.275393808	32.0	10733	2146.68
31010	490	63.3	11622	490	23.71836735	231.7	20687	1591.32
9160	185	49.5	6650	185	35.94594595	351.2	11837	2367.4
30030	487	61.7	11622	487	23.86447639	233.1	20687	1591.32
6450	185	34.9	7385	185	39.91891892	390.0	13145	2629.06
23058	504	45.8	11414	504	22.6468254	221.2	20317	1562.84
6625	185	35.8	4390	185	23.72972973	231.8	7814	1562.84
34048	504	67.6	8827	504	17.51388889	171.1	15712	1208.62
63479	1492	42.5	28500	1492	19.10187668	186.6	50730	2670
49230	851	57.8	16140	851	18.96592244	185.3	28729	2872.92
49230	851	57.8	16140	851	18.96592244	185.3	28729	2872.92
					-	-	-	-
6127	386	15.9	3820	386	9.896373057	96.7	6800	3399.8
20804	599	34.7	8445	451	18.72505543	182.9	15032	3006.42
25088	770	32.6	11640	618	18.83495146	184.0	20719	3453.2
12552	214	58.7	4498	214	21.01869159	205.3	8006	4003.22
12552	214	58.7	4498	214	21.01869159	205.3	8006	4003.22
12552	214	58.7	4498	214	21.01869159	205.3	8006	8006.44
					-	-	-	-
66456	1597	41.6	38900	1597	24.35817157	238.0	69242	3462.1
30570	776	39.4	9520	776	12.26804124	119.8	16946	1694.56
30380	804	37.8	11870	804	14.76368159	144.2	21129	2112.86
166859	1934	86.3	50413	1934	26.06670114	254.6	89735	8973.514
26810	684	39.2	14816	684	21.66081871	211.6	26372	3767.497143
67936	2016	33.7	39680	2016	19.68253968	192.3	70630	2207.2
66624	2017	33.0	38347	2017	19.01189886	185.7	68258	2133.051875
86633	2520	34.4	49880	2520	19.79365079	193.4	88786	2219.66
77811	2226	35.0	46620	2226	20.94339623	204.6	82984	2440.694118
23728	625	38.0	11824	625	18.9184	184.8	21047	2630.84
39606	1102	35.9	26110	1102	23.69328494	231.5	46476	3319.7
23728	625	38.0	11824	625	18.9184	184.8	21047	2630.84
39606	1102	35.9	26110	1102	23.69328494	231.5	46476	3319.7
23728	625	38.0	11824	625	18.9184	184.8	21047	2630.84
39606	1102	35.9	26110	1102	23.69328494	231.5	46476	3319.7
22203	415	53.5	13572	415	32.70361446	319.5	24158	4831.632
14889	410	36.3	11150	410	27.19512195	265.7	19847	3969.4
19215	500	38.4	10315	500	20.63	201.5	18361	3060.116667
13300	410	32.4	9420	410	22.97560976	224.4	16768	3353.52
16352	474	34.5	8540	474	18.01687764	176.0	15201	3040.24
23912	664	36.0	8792	664	13.24096386	129.4	15650	1956.22
21968	695	31.6	7992	695	11.49928058	112.3	14226	1778.22
22688	664	34.2	9480	664	14.27710843	139.5	16874	2109.3
36102	2660	13.6	16580	2660	6.233082707	60.9	29512	819.7888889
23728	625	38.0	11824	625	18.9184	184.8	21047	2630.84
23728	625	38.0	11824	625	18.9184	184.8	21047	2630.84
23728	625	38.0	11824	625	18.9184	184.8	21047	2630.84
23728	625	38.0	11824	625	18.9184	184.8	21047	2630.84
23728	625	38.0	11824	625	18.9184	184.8	21047	2630.84
23728	625	38.0	11824	625	18.9184	184.8	21047	2630.84
29312	488	60.1	10536	488	21.59016393	210.9	18754	2679.154286
5937	178	33.4	5300	178	29.7752809	290.9	9434	4717
7639	178	42.9	5300	178	29.7752809	290.9	9434	4717
5634	178	31.7	5300	178	29.7752809	290.9	9434	4717
8201	178	46.1	5300	178	29.7752809	290.9	9434	4717
6173	178	34.7	5300	178	29.7752809	290.9	9434	4717
7262.5	150	48.4	4317	150	28.78	281.2	7684	3842.13
20840	488	42.7	10600	488	21.72131148	212.2	18868	2695.428571
39693	1146	34.6	23884	1146	20.84118674	203.6	42514	3036.68
12921	318	40.6	5984	318	18.81761006	183.8	10652	2662.88
10826	328	33.0	6384	328	19.46341463	190.1	11364	2840.88
11379	329	34.6	8048	329	24.46200608	239.0	14325	3581.36
11188	340	32.9	5392	340	15.85882353	154.9	9598	2399.44
7262.5	150	48.4	4317	150	28.78	281.2	7684	3842.13
22664	488	46.4	9376	488	19.21311475	187.7	16689	2086.16
20080	486	41.3	12416	486	25.5473251	249.6	22100	2762.56
32424	901	36.0	18900	901	20.97669256	204.9	33642	3364.2
28980	504	57.5	8040	504	15.95238095	155.8	14311	1788.9
29190	882	33.1	18425	882	20.89002268	204.1	32797	3279.65
8202.5	150	54.7	4317	150	28.78	281.2	7684	3842.13
8202.5	150	54.7	5946	150	39.64	387.2	10584	5291.94
18944	488	38.8	10968	488	22.47540984	219.6	19523	2440.38
18056	488	37.0	9752	488	19.98360656	195.2	17359	2169.82
13909	492	28.3	9149	492	18.59552846	181.7	16285	2035.6525
9500	168.5	56.4	8919	168.5	52.93175074	517.1	15876	7937.91
9500	168.5	56.4	8919	168.5	52.93175074	517.1	15876	7937.91
8664	312	27.8	8024	312	25.71794872	251.2	14283	1785.34
27356	546	50.1	16506	546	30.23076923	295.3	29381	2098.62
29425	390	75.4	9100	390	23.33333333	227.9	16198	1619.8
17192	504	34.1	9104	504	18.06349206	176.5	16205	2025.64

Neighbourhood	Block number	Function	House typology	Stakeholder	S. classification	No. of Dwellings	Year of construction	Storeys number	Type of roof	Footprint m2
Buurt 3	18308		Rowhouses	Social Rental	Eigen haard	8	1952	3	Open Gable	301
Buurt 3	23563	Mosque	Other			1	1956			584
Buurt 3	18406		Rowhouses	Social Rental	Rochdale	7	1953	1	Flat	391
Buurt 3	18126		Rowhouses	Social Rental	Rochdale	11	1953	1	Flat	561
Buurt 3	17955		Rowhouses	Social Rental	Rochdale	8	1953	2	Open Gable	325
Buurt 3	19017		Rowhouses	Social Rental	Rochdale	14	1953	2	Open Gable	768
Buurt 3	18557		Rowhouses	Social Rental	Eigen haard	8	1953	3	Open Gable	338
Buurt 3	18958		Rowhouses	Social Rental	Eigen haard	14	1953	2	Open Gable	686
Buurt 3	18265		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	307
Buurt 3	18680		Multifamily house	Social Rental	Rochdale	36	1953	4	Open Gable	888
Buurt 3	18611		Multifamily house	Social Rental	Rochdale	36	1953	4	Open Gable	881
Buurt 3	23093	Mosque	Other				1958			1869
Buurt 3	18203		Rowhouses	Social Rental	Eigen haard	10	1953	3	Open Gable	586
Buurt 3	18304		Rowhouses	Social Rental	Eigen haard	8	1953	3	Open Gable	340
Buurt 3	18202		Rowhouses	Social Rental	Eigen haard	10	1952	3	Open Gable	550
Buurt 3	18305		Rowhouses	Social Rental	Eigen haard	8	1952	3	Open Gable	317
Buurt 3	18387		Rowhouses	Social Rental	Rochdale	8	1953	1	Flat	317
Buurt 3	18395		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	377
Buurt 3	18312		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	381
Buurt 3	18394		Rowhouses	Social Rental	Eigen haard	8	1953	3	Open Gable	388
Buurt 3	18347		Rowhouses	Social Rental	Eigen haard	8	1953	3	Open Gable	410
Buurt 3	18348		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	390
Buurt 3	18266		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	358
Buurt 3	18267		Rowhouses	Social Rental	Eigen haard	8	1953	3	Open Gable	278
Buurt 3	18306		Rowhouses	Social Rental	Eigen haard	8	1953	3	Open Gable	296
Buurt 3	23091		Other				1985			355
Buurt 3	17997		Rowhouses	Social Rental	Rochdale	8	1953	1	Flat	441
Buurt 3	18397		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	364
Buurt 3	18437		Rowhouses	Social Rental	Eigen haard	8	1953	3	Open Gable	328
Buurt 3	18438		Rowhouses	Social Rental	Rochdale	8	1953	3	Open Gable	376
Buurt 3	18311		Rowhouses	Social Rental	Eigen haard	8	1953	3	Open Gable	289
Buurt 3	18307		Rowhouses	Social Rental	Eigen haard	8	1952	3	Open Gable	286
Buurt 3	18707		Apartment blocks Portiekflat	Social Rental	Eigen haard	30	1954	4	Open Gable	626
Buurt 3	18709		Apartment blocks Portiekflat	Social Rental	Eigen haard	30	1954	4	Open Gable	635
Buurt 3	18708		Apartment blocks Portiekflat	Social Rental	Eigen haard	30	1954	4	Open Gable	614
Buurt 3	18706		Apartment blocks Portiekflat	Social Rental	Eigen haard	30	1954	4	Open Gable	720
Buurt 3	23091		Other				2003			570
Buurt 3	18769		Apartment blocks Portiekflat	Social Rental	Eigen haard	30	1954	4	Open Gable	733
Buurt 3	18801		Apartment blocks Portiekflat	Social Rental	Eigen haard	30	1954	4	Open Gable	671
Buurt 3	18798		Apartment blocks Portiekflat	Social Rental	Eigen haard	30	1954	4	Open Gable	687
Buurt 3	18880		Apartment blocks Portiekflat	Social Rental	Eigen haard	30	1954	4	Open Gable	660
Buurt 3	19016		Apartment blocks Portiekflat	Social Rental	Eigen haard	30	1954	4	Open Gable	657
Buurt 3	18207		Apartment blocks Portiekflat	Social Rental	Rochdale	20	1953	3	Flat	519
Buurt 3	18734		Apartment blocks Portiekflat	Social Rental	Rochdale	18	1953	3	Flat	586
Buurt 3	18666		Apartment blocks Portiekflat	Social Rental	Rochdale	20	1953	3	Flat	523
Buurt 3	18733		Apartment blocks Portiekflat	Social Rental	Eigen haard	20	1953	3	Flat	584
Buurt 3	18664		Apartment blocks Portiekflat	Social Rental	Eigen haard	20	1953	3	Flat	497
Buurt 3	18735		Apartment blocks Portiekflat	Social Rental	Eigen haard	18	1953	3	Flat	560
Buurt 3	18665		Apartment blocks Portiekflat	Social Rental	Eigen haard	22	1953	3	Flat	486
Buurt 3	18369		Apartment blocks Portiekflat	Social Rental	Rochdale	18	1953	3	Open Gable	470
Buurt 3	18681		Apartment blocks Portiekflat	Social Rental	Rochdale	26	1953	3	Open Gable	622
Buurt 3	18854		Apartment blocks Portiekflat	Social Rental	Rochdale	20	1953	3	Flat	556
Buurt 3	18229		Apartment blocks Portiekflat	Social Rental	Rochdale	20	1953	3	Flat	531
Buurt 3	18853		Apartment blocks Portiekflat	Social Rental	Eigen haard	20	1953	3	Flat	559
Buurt 3	18227		Apartment blocks Portiekflat	Social Rental	Eigen haard	21	1953	3	Flat	488
Buurt 3	18852		Apartment blocks Portiekflat	Social Rental	Eigen haard	19	1953	3	Flat	567
Buurt 3	18228		Apartment blocks Portiekflat	Social Rental	Eigen haard	21	1952	3	Flat	505
Buurt 3	18808		Rowhouses	Social Rental	Eigen haard	9	1954	2	Flat	995
Buurt 3	18910		Rowhouses	Social Rental	Eigen haard	21	1954	2	Flat	2616
Buurt 2	18850	Retail	Other				1958	2		17903
Buurt 2	18940	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	56	1953	5	Flat	963
Buurt 2	16709	Residential	Multifamily house	Owner Occupied		26	1958	4	Flat	1067
Buurt 2	19064	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	32	1953	5	Flat	1276
Buurt 2	25093	Museum	Other			1	1967			1078
Buurt 2	23523	Retail	Other			1	1954			1585
Buurt 2	19076	Residential	Multifamily house	Social Rental	Eigen haard	185	1953	5	Varied	4975
Buurt 2	18810	Residential	Apartment blocks Portiekflat	Social Rental	Eigen haard	24	1953	4	Open Gable	525
Buurt 2	18807	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	24	1953	4	Open Gable	525
Buurt 2	19075	Residential	Multifamily house	Social Rental	Rochdale	201	1953	5	Varied	5012
Buurt 2	19024	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	48	1953	5	Open Gable	907
Buurt 2	19023	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	48	1953	5	Open Gable	915
Buurt 2	23499	School	Other	Social Rental		1	1954			1054
Buurt 2	19021	Residential	Apartment blocks Portiekflat	Social Rental	Alliantie	56	1953	5	Open Gable	680
Buurt 2	19053	Residential	Apartment blocks Portiekflat	Social Rental	Alliantie	56	1953	5	Open Gable	716
Buurt 2	18682	Residential	Apartment blocks Portiekflat	Social Rental	Alliantie	56	1953	5	Flat	860
Buurt 2	18683	Residential	Apartment blocks Portiekflat	Social Rental	Alliantie	56	1953	5	Flat	856
Buurt 2	18685	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	56	1953	5	Flat	906
Buurt 2	18684	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	56	1953	5	Flat	838
Buurt 2	19020	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	56	1953	5	Open Gable	720
Buurt 2	19018	Residential	Apartment blocks Portiekflat	Social Rental	Rochdale	56	1953	5	Open Gable	741
Buurt 2	18975	Residential	Apartment blocks Portiekflat	Owner Occupied		22	1994	5	Flat	528
Buurt 2	18950	Residential	Apartment blocks Portiekflat	Owner Occupied		22	1995	5	Flat	528
Buurt 2	18703	Residential	Multifamily house	Owner Occupied		50	1995	11	Flat	627
Buurt 2	16750	Residential	Multifamily house	Owner Occupied		50	1995	11	Flat	643

Electricity consumption kWh	Use surface m2	kWh/m2	Gas consumption m3	Use surface m2	Consumption average per m2	Heating Energy kWh/m2	Gas CO2 emmisions m3	CO2 emission per dwelling
18200	502	36.3	10288	502	20.4940239	200.2	18313	2289.08
					-	-	-	-
9163	273	33.6	7469	273	27.35897436	267.3	13295	1899.26
15939	429	37.2	14487	429	33.76923077	329.9	25787	2344.26
15528	504	30.8	8744	504	17.34920635	169.5	15564	1945.54
40940	1217	33.6	21206	1217	17.42481512	170.2	37747	2696.191429
22736	520	43.7	13024	520	25.04615385	244.7	23183	2897.84
44167	1223	36.1	25288	1223	20.67702371	202.0	45013	3215.188571
16752	504	33.2	10240	504	20.31746032	198.5	18227	2278.4
79883	2184	36.6	46908	2184	21.47802198	209.8	83496	2319.34
73008	2187	33.4	42228	2187	19.30864198	188.6	75166	2087.94
					-	-	-	-
30450	882	34.5	18203	882	20.638322	201.6	32401	3240.134
19936	488	40.9	18304	488	37.50819672	366.4	32581	4072.64
34587	882	39.2	19257	882	21.83333333	213.3	34277	3427.746
28200	488	57.8	10800	488	22.13114754	216.2	19224	2403
8064	234	34.5	7626	234	32.58974359	318.4	13574	1696.785
15312	504	30.4	9616	504	19.07936508	186.4	17116	2139.56
23216	504	46.1	9968	504	19.77777778	193.2	17743	2217.88
20880	488	42.8	13296	488	27.24590164	266.2	23667	2958.36
18496	488	37.9	14824	488	30.37704918	296.8	26387	3298.34
24152	504	47.9	8120	504	16.11111111	157.4	14454	1806.7
28936	1133	25.5	11224	1133	9.906443071	96.8	19979	2497.34
16600	488	34.0	11504	488	23.57377049	230.3	20477	2559.64
16728	488	34.3	8328	488	17.06557377	166.7	14824	1852.98
					-	-	-	-
13432	312	43.1	6832	312	21.8974359	213.9	12161	1520.12
17672	522	33.9	10424	522	19.96934866	195.1	18555	2319.34
15080	492	30.7	9672	492	19.65853659	192.0	17216	2152.02
18592	488	38.1	9872	488	20.2295082	197.6	17572	2196.52
14616	488	30.0	9664	488	19.80327869	193.5	17202	2150.24
22000	494	44.5	10768	494	21.79757085	212.9	19167	2395.88
72756	1942	37.5	39798	1942	20.49330587	200.2	70840	2361.348
72756	1942	37.5	39798	1942	20.49330587	200.2	70840	2361.348
72756	1942	37.5	39798	1942	20.49330587	200.2	70840	2361.348
72756	1942	37.5	39798	1942	20.49330587	200.2	70840	2361.348
					-	-	-	-
54715	1560	35.1	35700	1560	22.88461538	223.6	63546	2118.2
54715	1560	35.1	37950	1560	24.32692308	237.6	67551	2251.7
54715	1560	35.1	38370	1560	24.59615385	240.3	68299	2276.62
54715	1560	35.1	34620	1560	22.19230769	216.8	61624	2054.12
54715	1560	35.1	33960	1560	21.76923077	212.7	60449	2014.96
65032	1124	57.9	31731	1124	28.23042705	275.8	56481	2824.059
44180	1069	41.3	32338	1069	30.25070159	295.5	57562	3197.868889
50930	1124	45.3	32319	1124	28.75355872	280.9	57528	2876.391
35574	1061	33.5	23920	1061	22.54476909	220.2	42578	2128.88
51471	1124	45.8	20140	1124	17.91814947	175.0	35849	1792.46
34620	1062	32.6	33022	1062	31.09416196	303.8	58779	3265.508889
62146	1124	55.3	32714	1124	29.10498221	284.3	58231	2646.86
141322	1230	114.9	26982	1230	21.93658537	214.3	48028	2668.22
185360	1800	103.0	68978	1800	38.32111111	374.4	122781	4722.34
49245	1062	46.4	24820	1062	23.37099812	228.3	44180	2208.98
44132	1124	39.3	23310	1124	20.73843416	202.6	41492	2074.59
39228	1064	36.9	25000	1064	23.4962406	229.5	44500	2225
44330	1124	39.4	25767	1124	22.92437722	223.9	45865	2184.06
43220	1062	40.7	25479	1062	23.99152542	234.4	45353	2386.98
37884	1124	33.7	21735	1124	19.33718861	188.9	38688	1842.3
16461	945	17.4	9336	945	9.879365079	96.5	16618	1846.453333
37310	2616	14.3	15912	2616	6.082568807	59.4	28323	1348.731429
		#DIV/0!	222075		-	-	-	-
114492	3172	36.1	64904	3172	20.5	199.9	115529	2063.02
268470	2522	106.5	36774	2522	14.6	142.4	65458	2517.604615
148271	3712	39.9	79680	3712	21.5	209.7	141830	4432.2
356630	4512	79.0			-	-	-	-
21895		#DIV/0!			-	-	-	-
406896	13714	29.7	222185	13714	16.2	158.3	395489	2137.78
66325	2166	30.6	32760	2166	15.1	147.8	58313	2429.7
48400	2082	23.2	28796	2082	13.8	135.1	51257	2135.703333
487278	13188	36.9	223488	13188	16.9	165.5	397809	1979.147463
105700	2784	38.0	59643	2784	21.4	209.3	106165	2211.76125
120363	2784	43.2	60432	2784	21.7	212.1	107569	2241.02
325045	9084	35.8			-	-	-	-
107764	2514	42.9	54544	2491	21.9	213.9	97088	1733.72
109500	2491	44.0	59808	2491	24.0	234.6	106458	1901.04
118177	3094	38.2	54656	3094	17.7	172.6	97288	1737.28
136173	3064	44.4	55296	3119	17.7	173.2	98427	1757.622857
115652	3063	37.8	56784	3118	18.2	177.9	101076	1804.92
115130	3064	37.6	57008	3119	18.3	178.6	101474	1812.04
98484	2574	38.3	50736	2551	19.9	194.3	90310	1612.68
106790	2519	42.4	48160	2519	19.1	186.8	85725	1530.8
54303	1418	38.3	19888	1418	14.0	137.0	35401	1609.12
43999	1414	31.1	17787	1414	12.6	122.9	31661	1439.13
139332	4557	30.6	56661	4579	12.4	120.9	100857	2017.1316
140556	4579	30.7	46050	4557	10.1	98.7	81969	1639.38

APPENDIX B

Simple Static Beam Calculation

The calculation to determine the beam size was done through a simple beam static calculation to determine the second moment of area required given the total loadcase of the top-up, which includes dead-loads, primarily from the construction, and live loads. The approach was to analyse the worst loading case, which is shown in Figure xx, where you have the largest area of influence. This area was determined between the two midpoints of a floor spans. Then the load case was estimated by using standard residential loading requirements and using the construction specification to determine the dead-load. The results for the total load-case are summarized in Table A.1.

To calculate the 2nd moment of area the loading scenario considered was a uniformly distributed load as illustrated in Figure A.2, with a total load of 32.9kN/m (q). The formula

$$x = \frac{5qL^4}{384EI}$$

to determine the deflection is given as:

q = load (N/m)

L = Span (m)

E = Youngs Modulus N/m2

I = 2nd moment of area (m4)

The guidelines for steel beams for residential use indicate an allowable deflection of L/360, meaning x=2.8mm. As all other variables are known in the formula, we can solve for

$$I = \frac{5qL^4}{384Ex}$$

I by rearranging the formal to:

q = 32922N/m

L = 10m

E = 1.20x1011 N/m2

x = 0.028m

This results in a beam being required with at least 77160cm4. Using the Universal beam catalogue for steel, the standard beams available in the industry, three beams were found to be viable and complying with the specifications of the top-up project. These are summarized in Table 5.10.

	DEAD LOAD		*LIVE LOADS*			*TOTAL N/m*
	LOAD (N/m)	plus Safety factor (1.2)	*LOAD (N/m²)*	plus Safety factor (1.2)	*N/m (load multiplied by AI width 3.53m)*	
Level 1			1500	2250	7943	
Floor	3500	4200				
Wall	2550	3060				
Level 2			1500	2250	7943	
Floor	3500	4200				
Wall	1500	1800				
Roof	500	600	600	900	3177	
TOTALS N/m		13860			19062	**32922**

Table A.1: Table of Loads

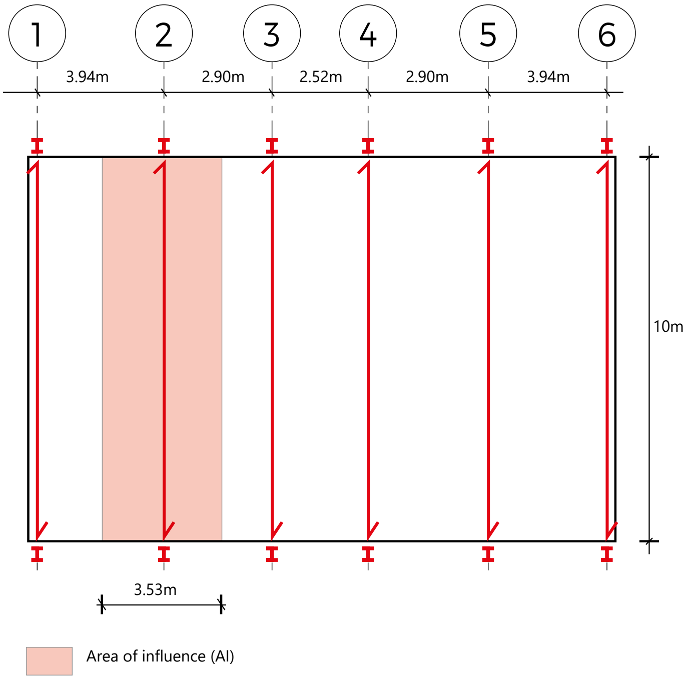


Figure A.1: Plan view of structural spans with wost ca

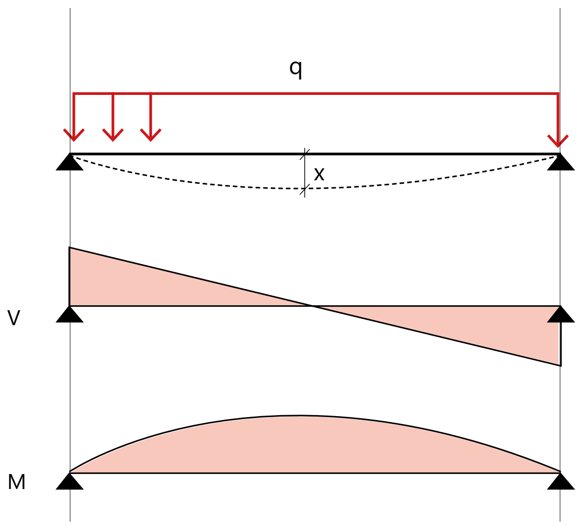


Figure A.2: Simple beam diagram of Top-up structure

STEEL PROFILES	DIMENSIONS		WEIGHT	2ND MOMENT OF AREA (x-AXIS)
1. UB 457x191x161	(mm)		kg/m	cm[4]
	b	199.4	161.4	79779
	h	492.0		
	tw	18.0		
	tf	32.0		
2. UC 356x406x235				
	b	394.8	235.1	79085
	h	381.0		
	tw	18.4		
	tf	30.2		
3. UC 305x305x283				
	b	322.2	289.9	78872
	h	365.3		
	tw	26.8		
	tf	44.1		

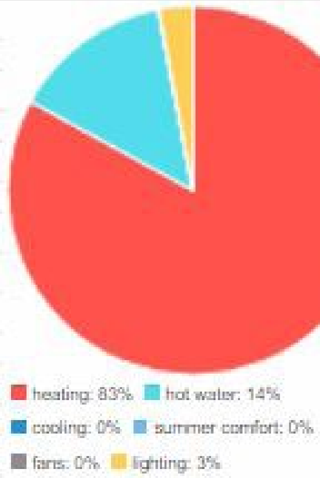
Table 5.10

APPENDIX C

Uniec Calculation Summary result

Existing Energy Performance

Annual amount of primary energy for the energy function		
heating (excluding auxiliary energy)	$E_{H; P}$	3,465,183 MJ
helper energy		103,834 MJ
hot water (excluding auxiliary energy)	$E_{W; P}$	590,184 MJ
helper energy		0 MJ
cooling (excluding auxiliary energy)	$E_{C; P}$	0 MJ
helper energy		0 MJ
summer comfort	$E_{SC; P}$	10,836 MJ
fans	$E_{V; P}$	0 MJ
lighting	$E_{L; P}$	138,931 MJ
exported electricity	$E_{P; exp; el}$	0 MJ
electricity generated on own plot	$E_{P; pr; us; el}$	0 MJ
in the area generated electricity	$E_{P; pr; del; el}$	0 MJ



Surfaces		
total area of use	$A_{g; to}$	3,015.00 m²
total loss area	A_{ls}	3,529.63 m²

Natural gas use (excluding cooking)	
building-based installations	115,308 m³aeq

Electricity use	
building-based installations	27,517 kWh
non-building equipment (stew)	84,516 kWh
electricity generated on own plot	0 kWh
exported electricity	0 kWh
TOTAL	112,034 kWh

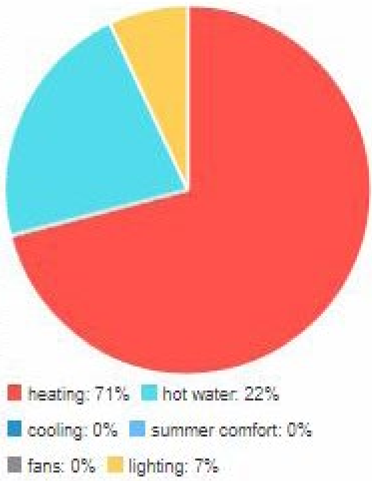
CO_2 emission		
CO_2 emission	m_{co2}	220,745 kg

Energy performance		
specific energy performance	EP	1,429 MJ / m²
characteristic energy use	E_{Ptot}	4,308,969 MJ
permissible characteristic energy use	$E_{P; adm; tot; nb}$	869,974 MJ
energy performance coefficient	EPC	2,573 -
energy performance coefficient	EPC	2.58 -

BENG indicators		
energy requirement	213.5 kWh / m²	✗
primary energy use	384.2 kWh / m²	✗
share of renewable energy	0 %	✗

Energy Performance Lable B

Annual amount of primary energy for the energy function		
heating (excluding auxiliary energy)	$E_{H; P}$	1,345,782 MJ
helper energy		94,977 MJ
hot water (excluding auxiliary energy)	$E_{W; P}$	437,173 MJ
helper energy		0 MJ
cooling (excluding auxiliary energy)	$E_{C; P}$	0 MJ
helper energy		0 MJ
summer comfort	$E_{SC; P}$	1,830 MJ
fans	$E_{V; P}$	0 MJ
lighting	$E_{L; P}$	138,931 MJ
exported electricity	$E_{P; exp; el}$	0 MJ
electricity generated on own plot	$E_{P; pr; us; el}$	0 MJ
in the area generated electricity	$E_{P; pr; del; el}$	0 MJ



Surfaces		
total area of use	$A_{g; to}$	3,015.00 m²
total loss area	A_{ls}	3,501,55 m²

Natural gas use (excluding cooking)	
building-based installations	50,695 m³aeq

Electricity use	
building-based installations	25,579 kWh
non-building equipment (stew)	84.516 kWh
electricity generated on own plot	0 kWh
exported electricity	0 kWh
TOTAL	110,096 kWh

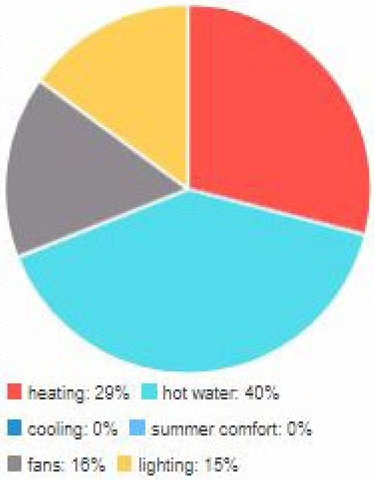
CO_2 emission		
CO_2 emission	m_{co2}	104,666 kg

Energy performance		
specific energy performance	EP	670 MJ / m²
characteristic energy use	E_{Ptot}	2,018,692 MJ
permissible characteristic energy use	$E_{P; adm; tot; nb}$	868,924 MJ
energy performance coefficient	EPC	1,208 -
energy performance coefficient	EPC	1.21 -

BENG indicators		
energy requirement	112.1 kWh / m²	✗
primary energy use	173.2 kWh / m²	✗
share of renewable energy	0 %	✗

Energy Performance Lable A++

Annual amount of primary energy for the energy function		
heating (excluding auxiliary energy)	$E_{H; P}$	188,036 MJ
helper energy		18405 MJ
hot water (excluding auxiliary energy)	$E_{W; P}$	285,590 MJ
helper energy		0 MJ
cooling (excluding auxiliary energy)	$E_{C; P}$	0 MJ
helper energy		0 MJ
summer comfort	$E_{SC; P}$	1,292 MJ
fans	$E_{V; P}$	118,455 MJ
lighting	$E_{L; P}$	110,389 MJ
exported electricity	$E_{P; exp; el}$	0 MJ
electricity generated on own plot	$E_{P; pr; us; el}$	0 MJ
in the area generated electricity	$E_{P; pr; dei; el}$	0 MJ



Surfaces		
total area of use	$A_{g; to}$	2,395.60 m²
total loss area	A_{ls}	3,459.95 m²

Natural gas use (excluding cooking)	
building-based installations	2.208 m³aeq

Electricity use	
building-based installations	69,934 kWh
non-building equipment (stew)	67,153 kWh
electricity generated on own plot	0 kWh
exported electricity	0 kWh
TOTAL	137,088 kWh

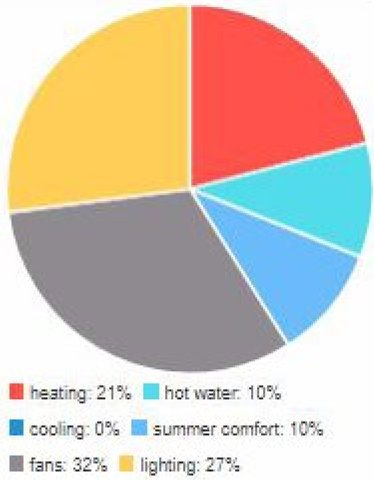
CO_2 emission		
CO_2 emission	m_{co2}	43,431 kg

Energy performance		
specific energy performance	EP	301 MJ / m²
characteristic energy use	E_{Ptot}	722.167 MJ
permissible characteristic energy use	$E_{P; adm; tot; nb}$	582,882 MJ
energy performance coefficient	EPC	0.496 -
energy performance coefficient	EPC	0.50 -

BENG indicators		
energy requirement	40.9 kWh / m²	✗
primary energy use	70.9 kWh / m²	✗
share of renewable energy	0 %	✗

Top-up Energy Performance Label A++

Annual amount of primary energy for the energy function		
heating (excluding auxiliary energy)	$E_{H; P}$	41,715 MJ
helper energy		17,727 MJ
hot water (excluding auxiliary energy)	$E_{W; P}$	17,648 MJ
helper energy		12,288 MJ
cooling (excluding auxiliary energy)	$E_{C; P}$	0 MJ
helper energy		0 MJ
summer comfort	$E_{SC; P}$	30,221 MJ
fans	$E_{V; P}$	91,813 MJ
lighting	$E_{L; P}$	77,783 MJ
exported electricity	$E_{P; exp; el}$	0 MJ
electricity generated on own plot	$E_{P; pr; us; el}$	0 MJ
in the area generated electricity	$E_{P; pr; dei; el}$	0 MJ



Surfaces		
total area of use	$A_{g; to}$	1,688.00 m²
total loss area	A_{ls}	2,282.10 m²

Natural gas use (excluding cooking)	
building-based installations	581 m³aeq

Electricity use	
building-based installations	29.162 kWh
non-building equipment (stew)	47.318 kWh
electricity generated on own plot	0 kWh
exported electricity	0 kWh
TOTAL	76,480 kWh

CO_2 emission		
CO_2 emission	m_{co2}	17,506 kg

Energy performance		
specific energy performance	EP	171 MJ / m²
characteristic energy use	E_{Ptot}	289,194 MJ
permissible characteristic energy use	$E_{P; adm; tot; nb}$	378,954 MJ
energy performance coefficient	EPC	0.306 -
energy performance coefficient	EPC	0.31 -

BENG indicators		
energy requirement	21.8 kWh / m²	✔
primary energy use	34.8 kWh / m²	✘
share of renewable energy	66 %	✔

Final Design Energy Performance

Jaarlijkse hoeveelheid primaire energie voor de energiefunctie		
verwarming (excl. hulpenergie)	$E_{H;P}$	223.442 MJ
hulpenergie		36.411 MJ
warmtapwater (excl. hulpenergie)	$E_{W;P}$	301.335 MJ
hulpenergie		16.384 MJ
koeling (excl. hulpenergie)	$E_{C;P}$	0 MJ
hulpenergie		0 MJ
zomercomfort	$E_{SC;P}$	2.167 MJ
ventilatoren	$E_{V;P}$	201.921 MJ
verlichting	$E_{L;P}$	188.172 MJ
geëxporteerde elektriciteit	$E_{P;exp;el}$	0 MJ
op eigen perceel opgewekte & verbruikte elektriciteit	$E_{P;pr;us;el}$	0 MJ
in het gebied opgewekte elektriciteit	$E_{P;pr;del;el}$	0 MJ

verwarming: 27% warmtapwater: 33%
koeling: 0% zomercomfort: 0%
ventilatoren: 21% verlichting: 19%

Oppervlakten		
totale gebruiksoppervlakte	$A_{g;tot}$	4.083,80 m²
totale verliesoppervlakte	A_{ls}	4.648,38 m²

Aardgasgebruik (exclusief koken)	
gebouwgebonden installaties	2.514 m³aeq

Elektriciteitsgebruik	
gebouwgebonden installaties	95.641 kWh
niet-gebouwgebonden apparatuur (stelpost)	114.471 kWh
op eigen perceel opgewekte & verbruikte elektriciteit	0 kWh
geëxporteerde electriciteit	0 kWh
TOTAAL	210.113 kWh

CO_2-emissie		
CO_2-emissie	m_{co2}	58.495 kg

Energieprestatie		
specifieke energieprestatie	EP	237 MJ/m²
karakteristiek energiegebruik	$E_{P;tot}$	969.832 MJ
toelaatbaar karakteristiek energiegebruik	$E_{P;adm;tot;nb}$	920.932 MJ
energieprestatiecoëfficiënt	EPC	0,422 -
energieprestatiecoëfficiënt	EPC	0,43 -

BENG indicatoren		
energiebehoefte	31,9 kWh/m²	✗
primair energiegebruik	53,2 kWh/m²	✗
aandeel hernieuwbare energie	42 %	✗