ARV

CLIMATE POSITIVE CIRCULAR COMMUNITIES

D4.2 DESIGN GUIDELINES FOR A CLIMATE POSITIVE CIRCULAR COMMUNITY IN UTRECHT

WP4 SUSTAINABLE BUILDING (RE) DESIGN

Rogier Laterveer

31.12.2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036723

PROJECT INFORMATION

Project acronym	**ARV**[1]
Project title	Climate Positive Circular Communities
Project number	869918
Coordinator	Norwegian University of Science and Technology / Inger Andresen
Website	www.GreenDeal-ARV.eu

DOCUMENT INFORMATION

Deliverable Number and Title	**D4.1 Design guidelines of a climate positive circular community in Oslo**			
Due Month	Month 12 (December 2022)			
Work Package Number and Title	WP 4. Sustainable Building (re) Design			
Task number and Title	Task 4.3 Integrated Circular Design of the Demo Project in Utrecht			
Dissemination Level	PU = Public			
Date of Delivery	31.12.2022			
Lead Author	Rogier Laterveer, UAS Utrecht			
Contributors	Wilko Planje, Karin Grooten, Martin van Dijkhuizen, Paul Das, Frank Stedenhouder			
Reviewers	Martin Volf, CVUT			
Status	First DRAFT version V.00 (Pending European Commission approval)			
Revision Log	**Version**	**Author**	**Main changes**	**Date**
	V.00	Rogier Laterveer Wilko Planje	1st Draft	15.12.2022
	V.01	Martin Volf	Major revision	20.12.2022
	V.02	Rogier Laterveer	Final Draft	21.12.2022
	V.03	Rogier Laterveer	Included final editing and revision application by Martin Volf	29.12.2022

[1] ARV is a Norwegian word meaning "heritage" or "legacy". It reflects the emphasis on circularity, a key aspect in reaching the project's main goal of boosting the building renovation rate in Europe.

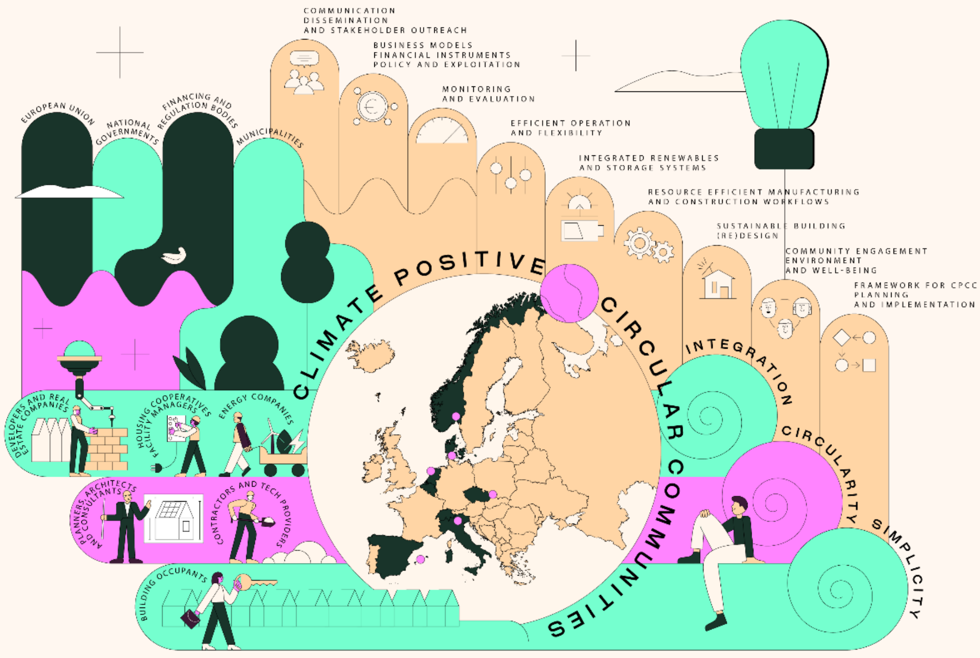
ABOUT THE ARV PROJECT

The vision of the ARV project is to contribute to speedy and wide scale implementation of Climate Positive Circular Communities (CPCC) where people can thrive and prosper for generations to come. The overall aim is to demonstrate and validate attractive, resilient, and affordable solutions for CPCC that will significantly speed up the deep energy renovations and the deployment of energy and climate measures in the construction and energy industries. To achieve this, the ARV project will employ a novel concept relying on a combination of 3 conceptual pillars, 6 demonstration projects, and 9 thematic focus areas.

The 3 conceptual pillars are integration, circularity, and simplicity. **Integration** in ARV means the coupling of people, buildings, and energy systems, through multi-stakeholder co-creation and use of innovative digital tools. **Circularity** in ARV means a systematic way of addressing circular economy through integrated use of Life Cycle Assessment, digital logbooks, and material banks. **Simplicity** in ARV means to make the solutions easy to understand and use for all stakeholders, from manufacturers to end-users.

The 6 demonstration projects are urban regeneration projects in 6 locations around Europe. They have been carefully selected to represent the different European climates and contexts, and due to their high ambitions in environmental, social, and economic sustainability. Renovation of social housing and public buildings are specifically focused. Together, they will demonstrate more than 50 innovations in more than 150,000 m² of buildings.

The 9 thematic focus areas are 1) Effective planning and implementation of CPCCs, 2) Enhancing citizen engagement, environment, and well-being, 3) Sustainable building re(design) 4) Resource efficient manufacturing and construction workflows, 5) Smart integration of renewables and storage systems, 6) Effective management of energy and flexibility, 7) Continuous monitoring and evaluation, 8) New business models and financial mechanisms, policy instruments and exploitation, and 9) Effective communication, dissemination, and stakeholder outreach.



The ARV project is an Innovation Action that has received funding under the Green Deal Call LC-GD-4-1-2020 - Building and renovating in an energy and resource efficient way. The project started in January 2022 and has a project period of 4 years, until December 2025. The Norwegian University of Science and Technology coordinates the project and involves 35 partners from 8 different European Countries.

EXECUTIVE SUMMARY OF THE PROJECT–UTRECHT, NETHERLAND

Name and Address	
Project type and ambition level	Retrofitting of medium high rise apartment building towards Positive Energy Building
Building types	The existing building is a typology of the porch flat and has a stacked block system with poured concrete as a main structure.
Location	Utrecht, Kanaleneiland, Rooseveltlaan and Alexander de Grotelaan
Building owner	Housing association Bo-Ex
Design team	Companies: Bos Installatiewerken (main developer Inside Out), Rc Panels, Mex Architects, iWell Research: University of Applied Sciences Utrecht, Utrecht University

Bo-Ex and BOS Installation works have already proven to be good cooperation partners in the past. From this sustainable partnership, the intention arose to comprehensively renovate high-rise flats. With the aim of reducing inconvenience for residents, saving costs, and accelerating the energy transition. This joint idea led to the formation of the Inside Out consortium. Six years later, with Inside Out, they have already helped more than ten housing associations with an integral approach to the energy transition. In the ARV Utrecht Demo project, the aim is to learn and use the knowledge of the Inside Out 1.0 and apply that to the demo sites in the city of Utrecht.

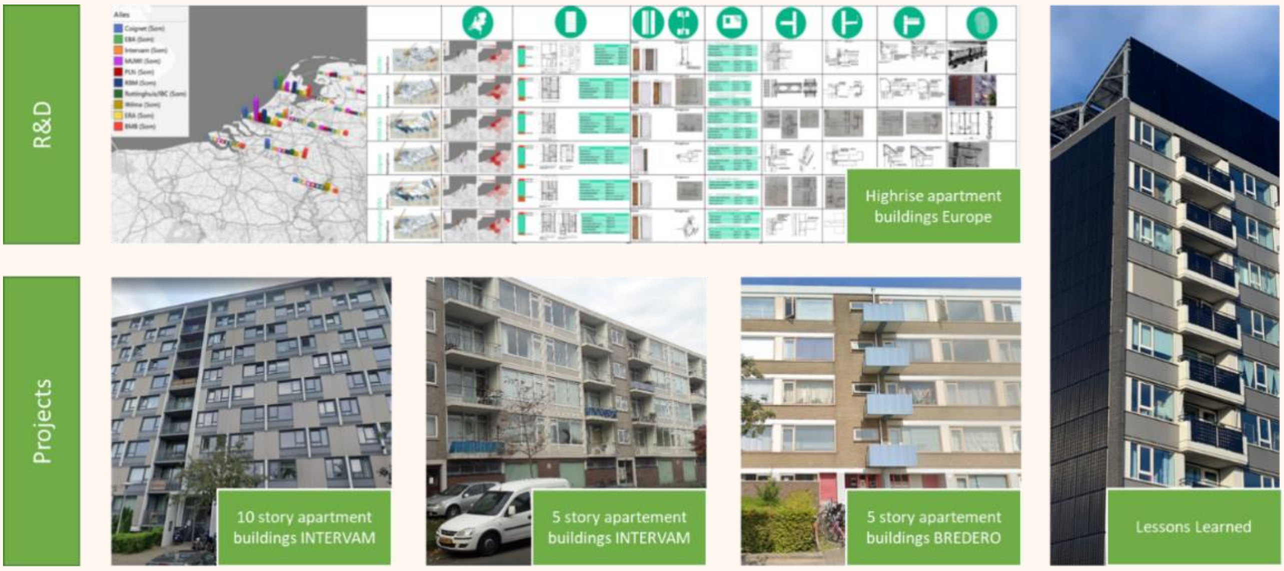


Figure 1. *R&D, Inside Out and Demo sites*

Key data:

Total size (floor area):	63 600 m²	Building/renovation timeline:	2021-2024
Investment cost:	€ 85 million	Project developers:	Bo-Ex & Mitros (ARV partners)

Owner	District	Type	Ambition	Planning	Retrofit	Dwellings	M2
Bo-Ex	Kanaleneiland	Bredero-4	PEB	2022	2023	65	5500
Bo-Ex	Kanaleneiland	Bredero-4	PEB	2022	2023	65	5500
Bo-Ex	Kanaleneiland	Bredero-4	PEB	2023	2024	65	5500
Bo-Ex	Kanaleneiland	Bredero-4	PEB	2023	2024	65	5500
Bo-Ex	Kanaleneiland	Intervam-4	NZEB to PEB	2022	2023	48	4900
Bo-Ex	Kanaleneiland	Intervam-4	NZEB to PEB	2022	2022	48	4900
Bo-Ex	Kanaleneiland	Intervam-4	NZEB to PEB	2022	2023	48	4900
Bo-Ex	Kanaleneiland	Intervam-4	NZEB to PEB	2022	2024	48	4900
Mitros	Overvecht	Intervam-10	NZEB to PEB	2023	2024	125	11000
Mitros	Overvecht	Intervam-10	NZEB to PEB	2023	2024	125	11000

Figure 2. *List of Utrecht demo buildings*

The demo sites are located in two neighbourhoods in the city of Utrecht: Kanaleneiland and Overvecht.

Figure 3. *Map of the demo area's*

This is the first edition of the design guidelines of a climate positive circular community in Utrecht. The report will be revised and supplemented annually (2023 and 2024).

TABLE OF CONTENTS

INTRODUCTION

In Task 4.3 as a Utrecht demo we work towards an Integrated Circular Design. The activities extend from month 1 to month 36 with a housing association Bo-Ex, companies Rc Panels, Bos Groep and Mex.
The demo actions in Utrecht focus on resource efficient, systematic retrofitting of four mid residential apartment buildings from the 1960s into Positive Energy Buildings embedded in a green neighbourhood. The innovations & research will assess the current retrofitting approach of
Inside-Out 1.0 (previously applied in one nationally funded project ending in 2021) and will develop application in the Inside-Out concept 2.0. The integrated design will include specific building components that result in 30% cost reduction compared to traditional systems and will reduce GHGs substantially. To achieve these goals the re-design will focus on roof, façade, and balcony systems by exploring the following subjects:

- The retrofit solutions will be designed for industrialization and will be scalable to serve different post war building typologies, such as 4 story, 6 story &10 story high-rise and other façade characteristics, through modular & adaptable roof, façade & balcony sections.
- For four mid-rise residential apartment buildings (type Bredero-4) the Inside-Out 2.0 retrofit solution will be designed and tailor made.
- For four mid-rise residential apartment buildings (type Intervam-4) and two high-rise residential apartment buildings (type Intervam-10) the HeMuBo retrofit solution, that is in pre-planning in 2022, will be assessed and advancements to this retrofit solution will be designed based on Inside-Out components.

The expected improvements relate to increased energy performance from NZEB to PEB and lower retrofitting time and costs through the application of Inside-Out components (energy and HVAC installations facades using sandwich panels) produced off-site and installed plug-and-play on-site and the application of additional BIPV / BAPV. The decision to implement these changes depends on outcomes of this task and external factors, such as existing contractual agreements between Bo-Ex, Mitros and their contractors (outside of ARV consortium) and the required investment.
Considered improvements are:

- Modular installation design which allows different types of heating & ventilation per dwelling related to the needs of the occupant &location.
- Renovation concepts to create the architectural diversity of appearance, adapted to the context. An important part is the architectural connection of design in post-war renovations and the design of the adaptable retrofitting solution.
- Design for standardization and flexibility of the interfaces connecting modules e.g., detailing. Including flexible façade fixing that gains a higher adaptation potential
- Design for infrastructure compactness, at the outside of the building & integrated in the roof, balcony & façade components, including connection of PV modules for optimal energy harvesting.
- Integration of material data storage in a resource track system i.e. materials passport.
- Design for minimal disruption: Users will have the choice to sleep in their apartments during the renovation.
- Design for Integrated Plug & Play installation solutions to link multiple facades (including integrated energy a/o ventilation installations) to enhance modularity and reduce the total cost of ownership.
- Demonstration of architectural and aesthetic plug-and-play integration of BIPV/BAPV solutions:
    - Analysis of current and new solutions of integration of PV in building components. Innovative BIPV solutions will be assessed on aesthetics and energy performance, and on feasibility for prefabrication, industrialization, integration & cost reduction, with varying features such as shape and colour
    - Definition & designing of BIPV in the pre-manufacturing process aiming to integrate PV in the factory, leading to a reduction in construction time and construction cost.
    - Definition & designing of BIPV in the pre-manufacturing process aiming to integrate PV in the factory, leading to a reduction in construction time and construction cost.
    - Definition and designing of plug-n-play BIPV, generating solutions for connecting cabling of PV panels and monitoring equipment between building components.

OVERVIEW

Situation

On Rooseveltlaan and Alexander de Grotelaan there are four Bredero flats, each of which has ***65*** dwellings. The appartement buildings are classified as porch flats. Each apartment building has five porches and also five residential floors. There are thirteen flats per porch. On the ground floor there is one large flat of 78 m^2 and thirteen storerooms. Floors one to four all have the same structure. Per floor, there are two relatively large flats of 71 m^2 and one smaller flat of 41 m^2.
The (flat) buildings are currently severely outdated, have an energy label G and therefore no longer meet the sustainability requirements of the future. Large-scale renovation cannot be avoided as a result.

Complication

New requirements for sustainability, high energy costs, shortage of rental/ temporary housing and a shortage of staff means Bo-Ex is ready for an integral solution for planned renovation.

Question

To this end, Bo-Ex and Inside Out started a journey to renovate the Bredero flats. Based on the Inside Out renovation concept, the aim was to renovate the flats to energy-neutral / energy-producing status.

VISION AND GOALS

VISION

Energy transition is the task of the century. An important part of the energy transition is making the housing stock more sustainable. This principle is accompanied by a number of bottlenecks such as rising energy prices; affordability of housing; rising construction costs; overheating in homes, etc. As a result, making the built environment sustainable is not moving fast enough. Traditional building methods, occupied housing and the increasing shortage of quality professionals do not help. Inside Out aims for a new integral way of designing and building so that, despite these barriers, a major step towards sustainability can be accelerated.

STEPWISE ENERGY NEUTRAL

In determining the sustainability steps, the sustainability strategy of "the New Steps strategy" developed by Prof A. van den Dobbelsteen was taken into account. Here, the first step is to optimise the thermal envelope and minimise unnecessary energy losses. The second step involves making optimal use of residual flows. When energy is still used, it should consist of renewable energy as much as possible. In the last step, finite energy sources should be used in an efficient way as possible.
Inside Out uses future-proof "No regret measures". No-regret measures are improvements that assume a desired end picture and reason backwards from there.

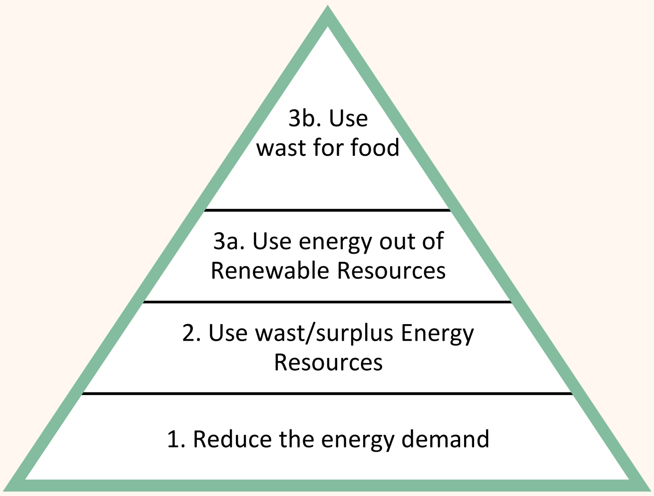


Figure 4. *Principle of the New Stepped Strategy [Dobbelsteen, 2008]*

INSIDE OUT 2.0

GENERAL

BUILDING BLOCKS

Step-by-step sustainability towards energy-neutral apartment buildings can be divided into several building blocks. Together, these building blocks form a comprehensive solution for energy-efficient apartment buildings. Depending on the customer's ambition level, one or more building blocks can be chosen. These are the following six building blocks:

- Facade module
- Roof module
- Balcony module
- Climate module
- Roof crown module
- Data module

The building blocks are integrally applicable and are factory-assembled with our established partners. The building blocks are suitable for any type of source system, both for low-temperature heating such as heat pumps or CHP, as well as for district heating. All building blocks then arrive at the construction site prefabricated and assembled at high speed. As a result, residents experience as little inconvenience as possible. In addition, this method of construction ensures that the energy transition is scalable. The Henriettedreef in Overvecht is the first (apartment) building where all building blocks have been realised. For the full project description and results of the installations, please refer to Annex 1.

FROM THE INSIDE OUT

The name Inside Out comes from the idea of renovating from the inside out. This means that as many existing installations as possible are taken from the inside of the house and integrated into the building blocks at the outside. For example, the Facade module can insulate, ventilate, heat and generate energy. By linking all these properties, all installations are immediately connected when the façade is installed. This increases construction speed, and the house remains habitable throughout the renovation. By renovating according to this philosophy, we at Inside Out can fulfil our mission: to *make the energy transition scalable and affordable.* In the core of this is making comfortable, affordable and self-sufficient stacked housing.

Figure 5. *Overview modules Inside Out 2022*

EXISTING SITUATION

SITUATIONS IN GENERAL

To create the necessary renovation solutions, it all starts with the identification of building typologies. The foundation of this approach lies in the research of Thijs Barkmeijer in 2017 and the follow up research on the characteristics of the building stock.

The base research was done in collaboration with the Stroomversnelling (a non-profit organisation also called Energiesprong) and is part of the necessity of the identification of the characteristics of the building stock to identify the need for standardization and flexibility. The goal is through the identification of standardization and flexibility to renovate as many homes as possible to PEB with an industrial approach. To achieve this goal, ARV works on all topics that affect this. The development of the high-rise table in Figure 6 has focused on the renovation of high-rise buildings in the Netherlands. This research focuses on one of the challenges in high-rise buildings. To this end, an answer was sought to the question: "What are the properties (technical, aesthetic, building physics) of the high-rise building systems that influence scaling up to PEB and what can be done with current solutions to accelerate this transition?" To answer this question, several research methods were applied.
Existing high-rise building systems from the period 1945-1975 were mapped. In total, there are 89 building systems, many of which were developed for low-rise buildings. There are 11 dominant building systems and have an 88% market share, about 211,000 houses, in high-rise system construction. More than half of this number is in the provinces North Holland and South Holland. This is where scale-up opportunities are greatest.

After systematic research based on 11 research nodes, the construction systems are known. These eleven building systems were built using different construction methods and therefore show a number of differences. All properties have been incorporated into system documents for each building system. All data was validated by fieldwork, among other methods. In the fieldwork, 125 buildings were analysed. This showed that the data is correct, with a note. In addition to the typical features, implementation variants were observed within the building systems in the building sections' end façade, longitudinal façade, and exterior space. These performance variants are system-independent and occur in all buildings regardless of the building system. Each of these building sections is implemented in only four variants.

The differences in execution within the building systems has meant that grouping based on nodes does not work because the building parts are leading for the renovation. Due to the four implementation variants, each building system requires four renovation principles, namely: insulate inside, insulate outside, demolish outer wall, and demolish entire façade. The implementation variant determines the renovation principle. The grouping was therefore carried out based on the building components and their implementation variants. In this grouping, the buildings, i.e., not the building systems, are grouped into the variants of the end façade, longitudinal façade, and exterior space.

The building component variants were combined with each other in practice. The only implementation variant where not all combinations are possible is the sandwich element. If the long façade consists of sandwich elements, so does the end façade. This situation only occurs in two building systems. As a result, the building systems can also be grouped into two groups with one group containing the sandwich elements and the other group containing the other systems.
As a result, the Inside Out concept can be scaled up to (other) high-rise buildings provided that the outdoor space, dimensional deviations in width and height, connections to outdoor spaces and concrete connections, execution variants and their required renovation principles, and the generation options to meet energy needs to be taken into account.

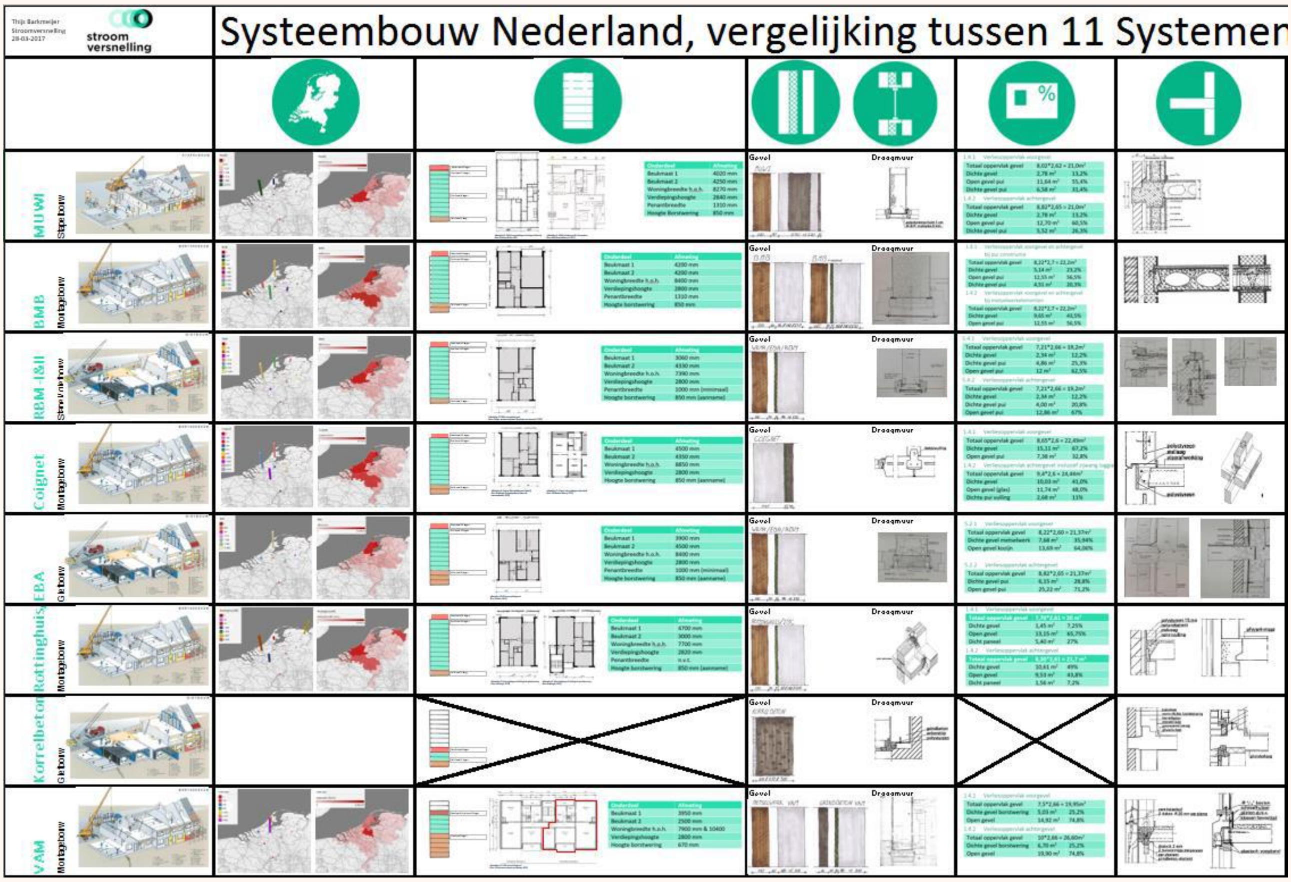


Figure 6 *Example for building systems of high-rise apartments*

BREDERO TYPES

Preliminary research investigated the current situation of the residential buildings. The (apartment) buildings are classified as porch flats. An apartment building has five porches and also five residential floors. There are thirteen flats per porch. On the ground floor, there is one large flat of 78 $m2$ and thirteen storerooms.
Floors one to four all have the same structure. On each floor, there are two relatively large flats of 71 $m2$ and one smaller flat of 41 $m2$.

Figure 7. *Bredero front façade*

Figure 8. *Bredero back facade*

Support structure

According to the existing drawings, it is not always clear how the load-bearing structure is constructed, so a study of the structural facade was carried out. The following points emerged from this investigation:

1) Too few cavity anchors in the facades;
2) Plenty of anchors in piers of longitudinal facade, though;
3) Masonry around concrete elements cracked due to expansion of material.
    a) Concrete too little dilation;
    b) Damage to concrete elements due to expansion;
4) Renovation anchors 'total wall dryfix' 10x220mm are sufficient for the façade to pass tensile tests;
5) Grouting poor quality, maintenance needed (possibly not needed due to Inside Out renovation).

Using the facade module, the above problems can be solved in one go. As a result, a building block immediately cuts a large cost item for maintenance work.

Installations

Heating and domestic hot water are controlled by a high-efficiency boiler. In the current situation, cooking is still done on gas. The radiators hang under the window frame in the parapet. There is also a tilting window in the window frame, which has a ventilation grille. There is also central extraction in the bathroom, kitchen and toilet. This extraction can be seen in Figure 9 (shaded green). The old chimneys, which have already been bricked up, are shaded blue. And finally, the meter boxes are shaded yellow.

Figure 9. *Central vertical ducts (as part of the HVAC system)*

Energetic quality

According to Milieu Centraal, the Bredero flats have an Energy Label G. This energy label is not future-proof, making a renovation towards integrated sustainability a requirement.

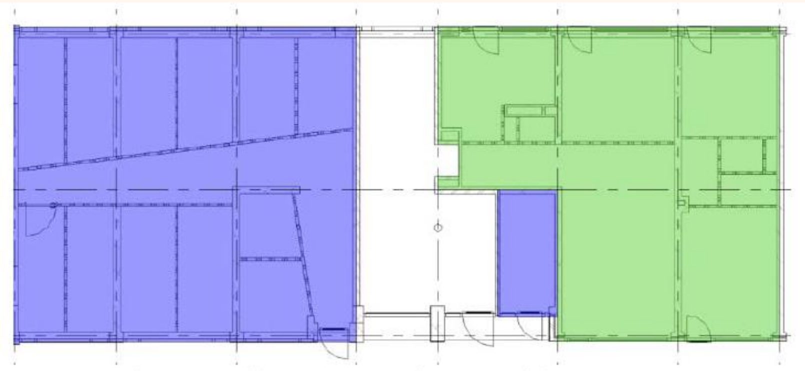


Figure 10. *Ground floor (level 0)*

Figure 11. *Floor plans, (Levels 1-4)*

GUIDELINES FOR RENOVATION

INTRODUCTION

To make the Brederoflats energy-neutral by 2050, a major sustainability effort is needed. Basically, there are two options to achieve this end result. One is to carry out the total renovation in one go or to renovate step-by-step to 2050-proof (flat) buildings. At Inside Out, we compare these two options to a train journey. The intercity direct train stops nowhere and takes the customer straight to the destination. The stopping train takes a bit longer and renovates one train station at a time. In this, the train stations are as renovation choices to which the Inside Out building blocks are applied and regular construction/maintenance work is carried out. If the stopping train is applied, the route is as follows:

- Station 1: A new coat
- Station 2: Renewable heat system
- Station 3: Outdoor living
- Station 4: Energy neutral
- Station 5: Smart building

Bo-Ex has announced that the Bredero flats will be renovated in one renovation phase. To make the renovation process clear, we explain for each station all the works, impact on residents and costs. The chapter concludes with a summary of all stations.

THE DESIGN

Mex Architects has produced a design for Roosevelt Avenue and Alexander de Grotelaan. This shows clearly how the Brederoflats will undergo an architectural improvement. The architects' reasoning behind the design is described as follows:

As architects, we believe that major maintenance should respect the quality of the original design and principles of a building and/or neighbourhood.
For the residential buildings on Roosevelt Avenue, it means that the masonry facades and the rhythm of the window openings are a recognisable theme. A building that is characteristic of the period in which it was built. A building that fits and connects with the look and feel of the neighbourhood.
The new smart facade is placed in front of the existing facades. We deliberately chose to retain the appearance of a masonry volume. The low windowsills in the windows overlooking the canal contribute to the residents' enjoyment of life and will also be retained. The technology in the smart façade is accessible from the outside. By executing the parapets in standing and tiled 'masonry' (mineral stone strips), the access hatches (clad in 'masonry') can be executed invisibly.
We retain the existing continuous facade openings in this design. We close part of the frame facade to reduce heating in the house. We then implement the closed part in a PV panel. Behind the panel is part of the smart technology. So a win-win. Less heating in the house, energy generation and space in the facade for technology.
The rhythm of the window, PV panel and pennant (at the location of the load-bearing walls) gives the building a clear structure inspired by the architectural character of the 1960s. The contemporary application of the masonry bond and the chosen colour scheme also make it a building of today.
The residential buildings on Roosevelt Avenue will have an appearance that fits in with the buildings in the neighbourhood. Buildings that can face the future.

Figure 12. *Presentation Architect concept design 2022*

COMPONENTS

A NEW COAT

The first step focuses on improving home quality. The house will be given a new coat to minimise heat demand and improve comfort. The measures can achieve a label jump from energy label G to A+.

RENOVATION WORK

As the first part of the envelope renovation, the Façade module is installed. The façade module consists of a number of components such as an LTV convector suitable for heating and cooling, decentralised CO_2 ventilation system with built-in heat exchanger in the living rooms. Furthermore, the south façade is equipped with solar screens to prevent overheating of the house. The Façade Module will be attached to the existing external cavity wall. The existing parapet can be retained, reducing demolition and asbestos costs and minimising inconvenience. The plastic window frames with triple glazing are also part of the Facade Module, which is attached to the existing structure as a prefabricated element. With the installation of the façade module, the façades of the Bredero flats will have a Rc value of 6 m^2K/W.
The second part of the shell renovation involves improving the roof. Thus, the roof is insulated, waterproofed with circular roofing and prepared for the installation of the Step 2 Climate module. With this renovation, Inside Out can guarantee that the roof will have an average Rc value of 8 m^2K/W.
Finally, maintenance work will need to be carried out to further reduce heat demand. Among these works are:

- bathroom, kitchen and toilets renovation (BKT);
- renew down pipes;
- replacing front doors and porches;
- replacing cavity anchors;
- renew meter box.
- post Asbestos remediation;
- places battery for peak load.

With the renovation of the envelope, the (flat) buildings meet all the Target Values set by the central government.

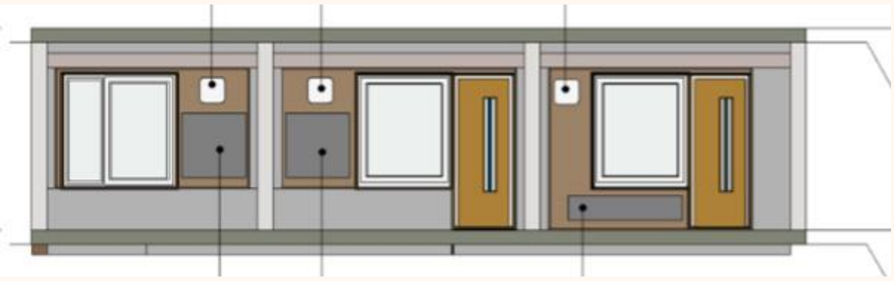


Figure 13. *Concept layout of facade module in Revit*

RESIDENTS' IMPACT

The integrated Facade module is attached to the existing facade like a new coat. The existing window frames are then removed, after which new plastic window frames are replaced. Each house will have a new facade within one week and will remain habitable for residents at all times. During the roof renovation, residents will experience minimal inconvenience. Roof works will take between 25 and 40 days. Maintenance work will be carried out within ten days.

Figure 14. *Presentation 3D detail of the facade*

SUSTAINABLE HEATING

The starting point of step 2 is to realise a gas-free heating source. To this end, Inside Out has developed the all-electric Climate module. The Climate module is a sustainable alternative to district heating where affordability can be controlled for tenants and the price of energy is not linked to the price of gas. This can be seen at Henriettedreef. Here, residents pay the same price for energy as before the energy crisis. The modular Climate module can be scaled up and down in its capacity and heating temperature. This makes the Climate module also applicable for flats where there is less budget available for minimising heat demand.

RENOVATION WORK

Each portico will be equipped with one Climate Module. The Climate Module includes a solar boiler, buffer tank, (air-water) heat pumps and electric boilers. The solar boiler is a system that uses thermal energy from the sun to heat hot water and central heating water. Heat pumps heat water by extracting heat from the air. The hot water from the heat pumps can be used for both the domestic hot water system and the central heating system. In cold winter months, the heat pumps cannot always extract enough

heat from the air, so the electric boilers can step in. All the hot water preheated by the various systems is stored in the buffer tank. Circulation pipes run from the buffer tank to the homes for hot water. A smart boiler then hangs in each dwelling to raise the water to 60 °C.
The envelope renovation at passing station 1 significantly reduces the heat demand per dwelling. This makes the dwelling suitable for low-temperature heating. Research through calculations showed that Bredero flats can already be heated with a supply temperature of 35- 40 °C at an outside temperature of -10 °C.
A major advantage of the Climate module is that it can make use of thermal heat in summer, significantly reducing energy consumption for domestic hot water. In addition, the design of the Climate module allows for thermal buffering. This also makes the Climate module suitable when the energy-saving scheme is phased out and energy buffering becomes more advantageous.

RESIDENTS' IMPACT

After the Climate Module is lifted (prefabricated and all) onto the roof, the electricity and water pipes are connected from the central supply as a power supply for the Climate Module. Next, the Climate Module is connected to the infrastructure in the roof. After that, the facades can be connected and can heat immediately after being connected. For the new domestic hot water system, a new boiler will be installed in the closet space of the house. A circulation pipe will be installed in the porch. The circulation pipe feeds hot water to the individual boilers.
The installation of the Climate module will therefore provide minimal inconvenience, as little work is done in the homes themselves. Inside Out can install the Climate module in a few days.

OUTDOOR LIVING

The third step focuses on the balcony renovation. Façade and cavity anchor surveys carried out by Nebest revealed that the balconies are technically in poor condition and cause thermal bridges. Residents themselves also noticed this. One resident writes the following about this:
"Very badly affected by mould in bedroom, combined with poor ventilation we feel it is unsafe for our baby. I suffer very badly from dampness and often have to collect water in buckets 2x a day and take it away. Balcony is very dirty and not tidy.".
The external space of the houses is also often a point of criticism. For instance, it is repeatedly mentioned that the balconies are small and often in poor condition. Renovation is therefore inevitable.

RENOVATION WORK

Inside Out has developed a Balcony module to replace the existing balcony. For Brederoflats, Inside Out will adapt the Balcony module to accommodate a fully freestanding balcony. To install this module, the existing balcony will be removed. The original construction drawings show that the existing balcony floor plates can be easily dismantled. The brackets can then be cut off, creating a flat façade. This is ideal for even faster installation of the Facade module, guaranteeing airtightness and removing thermal bridges. A larger freestanding balcony can then be installed. This new freestanding balcony gives space to create a larger outdoor space and ensures that the outdoor space is once again fit for the next 50 years.

IMPACT FOR RESIDENTS

The removal of the balconies will be integrated with the installation of the Facade module, minimising inconvenience. However, it cannot be prevented that residents will experience noise nuisance and temporarily be unable to use the outdoor space. On the other hand, residents will receive a new and larger balcony in return, increasing resident satisfaction.
The large new balcony also offers opportunities to use for the placement of temporary bathroom units. This will allow residents to stay in their homes even during the BKT renovation, reducing the need for guest houses for the renovation.

Figure 15. *Presentation 3D front facade*

ENERGY NEUTRAL

With the elaboration of the first three steps, the (flat) buildings have already made a big step towards sustainability. For instance, the (flat) buildings have been energetically and aesthetically improved, balconies renovated and connected to a sustainable heat source. The stopover at station 4 focuses on renewable energy generation. After passing station 4, the buildings can be characterised as energy-neutral homes. This means that as much energy is generated annually as is consumed by the residents.

ENERGY CALCULATION

The energy consumption of a home can be divided into four categories:

- Heating;
- Hot water;
- Central facilities (CVZ);
- Household energy.

The energy bundle for heating is determined with a Vabi-Elements calculation. In Vabi-Elements, the house is calculated and the expected energy consumption over the heating season is calculated. The bundle for hot water is the energy consumption required to have hot water. Here, an available amount of tap water per dwelling typology is taken into account. The domestic energy consumption is about the power needed for in the house. This is power for the washing machine, cooking and lighting. Finally, a bundle is included for the energy costs of the central facilities. This is for lighting in the stairwells, entrances, and storerooms.
When calculating the bundles, the applicable EPV rules were taken into account. According to the EPV rules, a home must generate at least as much energy sustainably as is needed for heating, hot water (15 kWh/m^2/year), auxiliary energy and domestic use (26 kWh/m^2/year). This is subject to a minimum of 1800 kWh and a maximum of 2600 kWh. By complying with the EPV rules, Bo-Ex can claim a maximum allowance of €1.51 per m^2 per month.

RENEWABLE ENERGY

To generate its total energy needs, Inside Out is installing 900 PV panels. These panels will be integrated into building elements at the end and longitudinal facades. Together with Mex Architects, a design was made in which standard full-black solar panels are incorporated next to the frame surface.

"The rhythm of window, PV panel and pennant gives the building a clear structure inspired by the architecture characteristic of the 1960s. The contemporary application of the masonry bond and the chosen colour scheme also make it a building of today" - Frank Stedehouder, Mex Architects

The roof will be fitted with PV frames. **Figure 16** shows a sketch of the PV design on the roof. There will be a raised roof arrangement to meet the energy requirements.

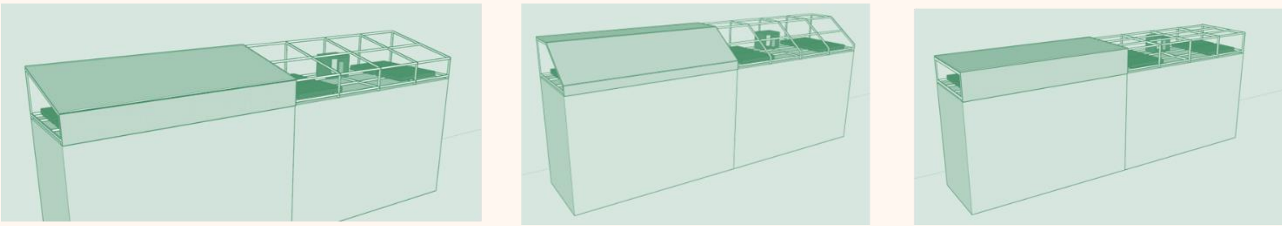


Figure 16. *Roof configurations*

OPPORTUNITIES

The EPV states that a minimum of 23 kWh/m^2 must be generated. A minimum of 1,800kWh and a maximum of 2,600 kWh has been introduced per dwelling. For Henriettedreef, it was concluded at the time that EPV rules were written for single-family houses and not multi-family houses. This is reflected in the measurement results for Henriettedreef. According to the EPV rules, the studios on Henriettedreef should generate a minimum of 1,800 kWh. The ESV was therefore created for Henriettedreef. A derivative of the EPV, but for domestic energy consumption with different calculation rules. For instance, the minimum energy to be generated is not 1,800 kWh but 1,500 kWh. This can reduce the required installed capacity of PV.

In addition, a change in the law is imminent which will make virtual balancing possible. Virtual balancing will ensure that only a few large inverters are needed, and no individual home connections need to be made. This will save costs, reduce inconvenience, and distribute power more fairly among tenants. This will prevent the greatest benefit from falling on the energy companies but on the housing association and its tenants. The law has not yet been passed, but the European-subsidised ARV project may provide a space for experimentation to explore these opportunities.

IMPACT RESIDENTS

The PV panels in the facade will be pre-mounted in the facades, so residents will not experience any additional inconvenience from this. To connect the solar panels to the homes, work will take place in the meter boxes. Holes will also have to be drilled so that cables can be drawn through them. Residents may experience inconvenience from this.

SMART BUILDING

The final station focuses on monitoring and management. Inside Out's Data Module ensures that the corporation is EPV entitled. All consumption is monitored according to the applicable requirements and can be viewed by residents in the Inside Out monitoring platform. Inside Out also plans to use the platform for coaching residents and additional explanation through instructional videos in multiple languages. This will enable the next step in helping residents with their new energy-efficient home.

MANAGEMENT AND MAINTENANCE

The monitoring data is not only used to understand residents' consumption. Inside Out also uses this data to maintain the Installations. Using the Data Module, Inside Out can intelligently control the heat pumps from a distance. This distributes running hours of the heat pumps, prevents unnecessary switching on of electrical elements and enables a higher COP. The smart control ensures better and longer life of the installations. This is reflected in the expected maintenance cycle for the installations. Monitoring data also allows maintenance to be signalled and preventive.

OPTIMISE

Inside Out is continuously developing new and sustainable insights of our system. Through artificial intelligence and internet of things, the new insights can be incorporated into the already running installations through updates. Thus, the building becomes smarter and smarter and performs more and more efficiently. The advantages of the Data module are:

- Ensuring energetic building performance;
- EPV entitled monitoring platform;
- Resident instructions and access to instructional videos;
- Longer plant life by distributing workload;
- Continuous performance optimisation of the system;
- Inside Out system updates.

Figure 17. *Example of the current monitoring module*

OPPORTUNITY

With the removal of net-metering in the future, it will become increasingly important to use and store power. Inside Out is working with partners to further develop the system to anticipate this. This will allow it to respond to grid congestion issues and provide a better financial business case when balancing is scaled down and eventually abolished.

ACKNOWLEDGEMENTS AND DISCLAIMER

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036723.

This deliverable contains information that reflects only the authors' views, and the European Commission/CINEA is not responsible for any use that may be made of the information it contains.

PARTNER LOGOS

WWW.GREENDEAL-ARV.EU