Industrial Energy Efficient Retrofitting of Resident Buildings in Cold Climates

D2.6
Demonstrator Roosendaal

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Deliverable History

This deliverable history should be removed from the document once it has been finalised. It can then be stored as a separate document on the server, next to the final version.

Version	Status	What's new?
03 May12	Template	Template for demo reports
25 May 14	Draft	First draft of the final report
2Jun14	Review Draft	Report ready for review by Schwörer and GWGM. Formatting changes by Birgitta
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D2.1 Demonstrator München

D2.2 Demonstrator Oulu

D2.3 Demonstrator Voiron

D2.4 Demonstrator Augsburg

D2.5 Demonstrator Halmstad

D2.6 Demonstrator Roosendaal

D2.7 Demonstrator London

Executive Summary

The demonstration project Kroeven Roosendaal, Netherlands is part of a larger regeneration project for the whole area, which includes demolition and new construction at strategic places, but focuses on major energy renovation of terraced houses built in the 1960-ies. The overall objective of the project is to achieve affordable and healthy homes in an attractive area, which can be exploited for another 40-50 years. Therefore passive renovation has been chosen as the main strategy to achieve a very low heat demand and thus affordable heating costs and a good indoor environment

The E2ReBuild demonstration concerns 50 houses, out of a total of 246 passive renovation and 90 new passive houses.

Prefabrication of façade and roof elements has been used as the main means of renovation, with the aim of reducing the disturbance of tenants, constant and high quality and good energy performance. The renovation approach includes much better insulation than current practice via the labelling system in the Netherlands requires. Healthy and comfortable indoor climate conditions were achieved through the installation of controlled mechanical ventilation with heat recovery. Airflows have been selected with the objective to have such a ventilation rate that the internal CO_2 emission level is well below the requirements for new homes.

The renovation process was special because it allowed a systematic preparation and on site implementation whilst the tenants could stay in their homes. The approach has been tested on a pilot renovation house, and was afterwards implemented as a large scale process. Once the renovation was up to speed four houses were renovated in one week. On one day the existing roof and windows were replaced by the new prefabricated roof and façade elements. Each day one truck load for one house arrived on site, and was mounted on the same day. The preparation and completion works have been more intrusive than the renovation itself.

The energy performance is as expected. Gas heating consumption for space heating, hot water and cooking reduced by 65%. Given that cooking is constant, and hot water reduced by 50% because of the solar thermal system, the space heat reduction is between 75 and 80%.

Energy savings have been ensured by the landlord in such way that it was guaranteed that the result of rent increase of € 65 per month would not exceed the value of the energy savings in the first five years. Less than 10% of the tenants made use of the guarantee. These were the tenants who accepted very low indoor temperatures before renovation, and thus had smaller savings than on average.

The landlord has made significant investments which will pay off during the extended exploitation period of 40- 50 years which would not have been the case if the houses were replaced with more expensive new homes. Also the rent increase partially contributes through the pay back. Because of the passive energy renovation the homes remain affordable in terms of rent and energy costs, and indoor climate conditions are very good. The main drawback is the initial investment, though in life cycle terms the exploitation of passively renovated homes is good.

Replication potential is large provided that further industrialisation, product development and implementation scale result in affordable investment costs. Findings from this project have already motivated suppliers from industry to launch products along these lines. There is a huge market at the scale of 2 million homes just in The Netherlands which can benefit from this approach, not to speak of the huge European application market, which is there once investment mechanisms aimed at integrated renovation methods are available.

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1 Introduction

1.1 E2ReBuild Demonstrations

The demonstration projects in E2ReBuild are the core of the project. E2ReBuild is driven by the demonstration projects, whereas research activities feed into the demonstrations, and results of the demos feed into the evaluation and lessons learned in other work packages. The results and conclusions from the demonstrations will be gathered to produce an industrial platform for energy efficient retrofitting (work package 6).

The objective of the work package 2 projects is to demonstrate seven high energy efficient innovative retrofitting technologies and measures for low energy performing buildings with typologies representative for a large geographical area in Europe.

Each project establishes and demonstrates sustainable renovation solutions that will reduce the energy use to fulfil at least the national limit values for new buildings according to the applicable legislation based on the Energy Performance of Buildings Directives (for 2010) and to reduce the space heat use by about 75%.

Monitoring and follow-up: Based on recommendations given by work package 5, monitoring takes place during at least one year within this project, in some cases for a longer period (also continuing after the completion of this project).

One of the main issues in initial refurbishment discussions concerns costs. This has been treated in depth in deliverable D3.4 *Holistic Strategies for Retrofit* where costs from all demonstration projects are reported, analysed and discussed[1].

The demonstrators are supported by work carried out in work packages 1, 3, 4 and 5.

This deliverable is defined as a “demonstrator”. This document is the written record of the achievement.

1.2 Demonstrator Roosendaal

De Kroeven in Roosendaal is an area with almost exclusively similar rental terraced houses. The houses were built in the 1960s and were in need of a significant renovation, to bring the houses to a good quality level and ready for a prolonged future use.

For many years the city of Roosendaal and Aramis AlleeWonen and its predecessors collaborated to develop a regeneration plan for De Kroeven. The municipal area vision for the larger area Groot Kroeven is based on a number of objectives for the area:

- supporting the spatial structure by adding building volume, a green lane structure and increasing the spaciousness;
- Increasing the variety of house types by strategic demolition, new construction throughout the area;
- Increasing the functional quality of public spaces by adding parking spaces, more usable green areas, and better maintenance

The transformation of the existing area Kroeven should therefore aim at

1. breaking the urban and architectural monotony (repetition of urban patterns and many identical terraced houses)
2. fundamentally increasing the integral living quality of the existing housing stock

[1] As report D3.4 is restricted, public information can be found in GEIER, SONJA; EHRBAR, DORIS; SCHWEHR, PETER (2014); Holistic Strategies for the Retrofit to Achieve Energy-efficient Residential Buildings. In: Proceedings 9th International Masonry Conference 2014. Guimarães (P)

3. developing a use and future value of the stock for another 25 to 40 years; an essential extended life time

The planning of the project took place in the period 2005 – 2008. Project execution of the measures such as demolition, renovation and redesign of public spaces commenced in 2009. In 2014 final completion of the public spaces takes place.

Figure 1: Part of the district Groot Kroeven, Roosendaal before renovation

Figure 2: The 50 demo houses in E2ReBuild are the most northern houses in grey. The other colours represent the new construction of patio houses, apartments and terraced houses

Woningstichting AlleeWonen, Roosendaal has renovated 246 existing terraced houses, according to the passive house renovation principle. This was the first time in The Netherlands that this principle was used at large scale in a renovation project.

The 50 houses which are part of the E2ReBuild, renovated in 2010 and 2011 have been made very energy efficient by full insulation at high standards, and achieving good airtightness standards. Insulation took place by adding new prefabricated timber framed elements to the façade and roof. The external leaf of the façade, and the roof have been demolished, the foundation has been adjusted before the prefab elements were placed. Foundation and floor have been insulated in situ.

Figure 3: Front elevation before renovation

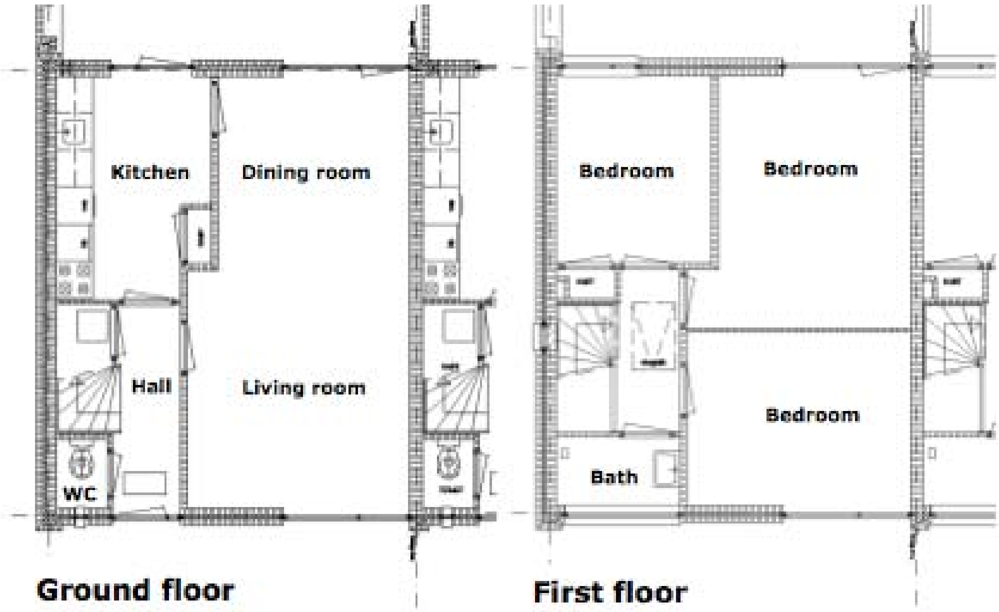

Figure 4: Floor plans before renovation

Façade and roof elements have been fabricated in a factory: insulation, window frames, glazing, doors, roofing material, roof window, service penetrations and a solar thermal collector all have been installed in the factory before transportation to the site. At the mounting day in a house existing windows, glazing, doors and the roof were demolished, and the new façade and roof elements were mounted at the same day. At the end of the day a house was weather, wind and watertight. The tenants did stay in their home during renovation, but in addition a resting space was offered during the mounting day

Figure 5: Front elevation after renovation

Figure 6: Floor plan after renovation

Also the heating and ventilation systems were modified. Ventilation altered from a natural supply and exhaust system into mechanical ventilation with heat recovery. An integrated passive house system was craned into the house when the roof was open. The system comprises of a small gas heater for space heating and hot water, mechanical ventilation with heat recovery and a (solar) storage system, which connects to the solar collectors in the prefabricated roof.

2 Energy Efficient Retrofitting

The demonstration project exceeds current practice by far, in achieving energy conservation through the technical solution that is used. Where standard practice refers to insulation levels at U values between 0,6 and 0,35 W/m^{2}K, the demonstrator shows that U values in the range of 0,15 – 0,10 for W/m^{2}K, combined with airtight construction, triple glazing and mechanical heat recovery is needed to achieve 80% reduction in space heat demand. The applied prefabricated solution points to the lesson that good quality and shorter renovation processes can easier be achieved in this way compared with traditional on site renovation work.

To bring existing houses at passive house envelope quality can be done by external or internal insulation or a combination of both. Most common today is the use external insulation on an existing façade, and roof insulation either inside or outside a roof, and in some cases renewing the full roof.

The innovation in the E2ReBuild project is the use of prefabricated timber frame elements, both for the façade and the roof. The elements have been industrially manufactured. The on-site works consist of demolition of old components such as window frames, glazing, doors, the external leaf of the cavity wall and roof, followed by foundation preparation works. After the one day installation of the new façade and roof elements only the final façade cladding has to be mounted. This process saves much time in the physical renovation work and a constant quality is better ensured.

Quality control has been a key issue in the process. All houses have been blowerdoor tested during the renovation, and afterwards. In this learning process critical connections have been identified and well-sealed. The overall airtightness value n50 is 1,0 in all houses. Also thermo graphic images have been made, but did not point to any critical detail. The insulation is smooth and well connected.

The expected achievements of the project are

- revitalized urban district which can be exploited a further 40-50 years
- (international) good practice example of advanced renovation using prefabricated solutions
- energy efficient homes
- significantly reduced energy bills
- comfortable and healthy homes
- affordable costs of living
- insight in real performance and conditions

The E2ReBuild project has made it possible to share the renovation approach with international partners. E2ReBuild also financially contributes to the project. The monitoring programme would not have been as detailed without E2ReBuild.

3 Retrofitting Process

Because the intended renovation process had not been used before at that scale, Aramis AlleeWonen has decided to follow an alternative way of procuring the project. In the design stage there has been collaboration with an architect and energy expert. To further prepare the project direct contacts with suppliers of relevant components has been sought. These suppliers brought their most recent knowledge and products to the table. In this stage a pilot renovation has been executed to learn about all practical details and problems which may happen during a passive house renovation project based on prefabrication.

Figure 7: A test house has been built before the large scale renovation took place to get used to the renovation method and details

Figure 8: Mounting of prefabricated façade element

Figure 9: Left: cross section of existing cavity wall. Right: cross section after placement of prefabricated façade element.

For the project renovation at full scale, including the 50 E2ReBuild demonstration houses, Aramis AlleeWonen divided the renovation approach into several parcels, and specialist suppliers were invited to make an offer for their parcel, but they should also be willing to collaborate with the other suppliers and form and integrated team. The four parcels were:

- Manufacturing and installing prefabricated façade and roof elements including window frames and doors and a solar thermal collector
- Installing mechanical ventilation with heat recovery, including a condensing gas boiler and solar storage
- Ground works, foundation preparation, floor insulation, external and renovation works coordination
- External cladding of the facades.

The suppliers did work as equal contractors instead as subcontractor under a main contractor. The team collaboration developed into a streamlined process, in particular in the phase of the mounting of façade and roof elements.

After renovating a few houses to get used to the process, the renovation works were carried out like a train running through the area. Every week four houses were done; every night one truck load with all façade and roof components arrived, and during the day one house got a new façade and roof. The last day of a week was used to complete outstanding works in the previous four houses.

Tenants have played a key role in the preparation of the project. The demand for an energy efficient renovation was first expressed by tenants who did not agree with a proposal for demolition and new construction and a very low profile renovation. Aramis AlleeWonen developed the energy renovation programme, and hired Nederlandse Woonbond, a national tenant representative organization, to support the tenants and ensure that proposals were beneficial to the tenants. Similar to other renovation schemes a 70% agreement among tenants is needed to implement a renovation scheme in all houses of a project. In order to convince the tenants, the projected energy savings have been guaranteed to the tenants by Aramis AlleeWonen. A rent increase of € 65,00 was agreed, which was on average be assumed to cover the anticipated savings. Only 10% of the tenants have applied for the guarantee. These were tenants who were relatively spoken energy efficient before renovation, by accepting low indoor temperatures. In 90% of the cases the expected savings exceeded the projected savings.

The renovation process based on prefabrication was in the interest of tenants, because the real intervention by demolishing the roof and existing windows and mounting new facades and roofs only took one day. That does not mean that there was no disturbance of tenants. In the three weeks before the renovation, ground works around the houses took place by digging a one meter wide ditch around a row of terraced houses. Before the renovation all tenants had to clear their loft and place all furniture at the first and second floor at least one meter from the façade.

Figure 10: Ditch around the houses to prepare for foundation works and perimeter insulation

Figure 11: Foundation prepared: ready for installation of prefabricated façade element.

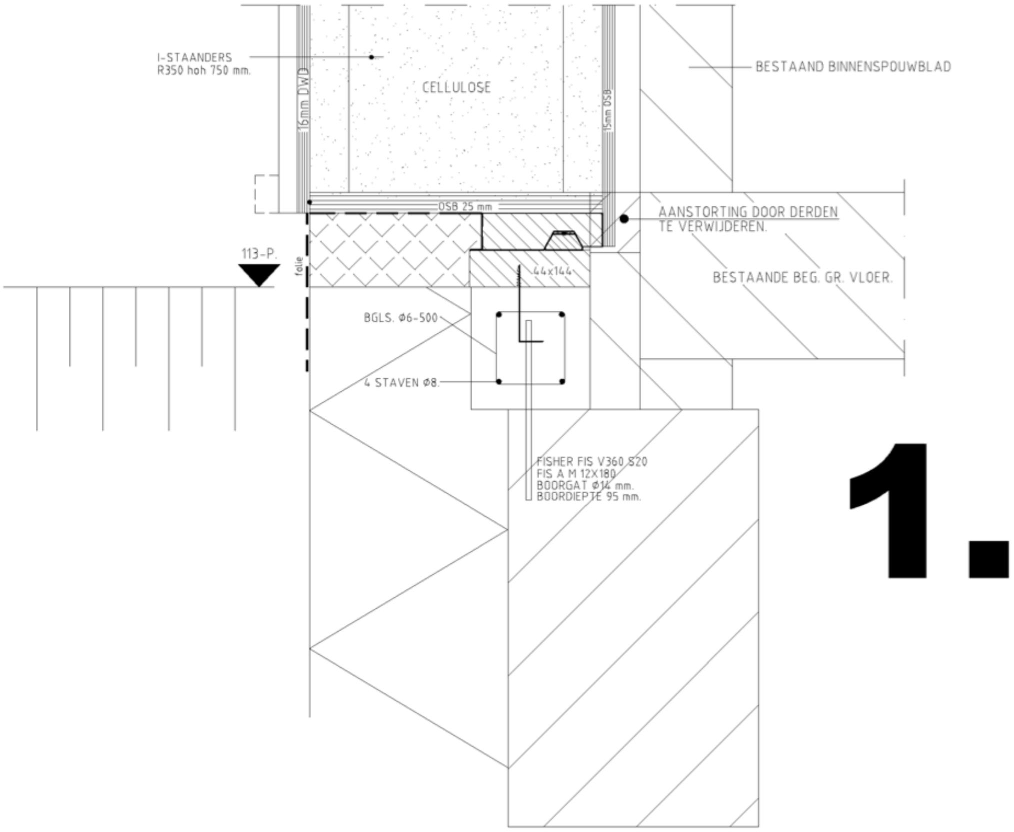

Figure 12: Working detail foundation and façade element

Figure 13: One truck load=one house ready for transportation at the factory

Figure 14: The solar collector and roofing material were pre-installed in the factory

Figure 15: The one day in which the roof and windows were dismantled (middle house). At the end of this day the house was weather and watertight with mounted roof and façade elements

As a special service tenants were offered a big bag for all stored goods in a loft they wished to get rid of. This big bag was craned from the loft, once the old roof was demolished. The new heating and ventilation equipment was craned into the loft. During the renovation new ventilation ducts had been made for the fresh air supply to the habitable spaces. Exhaust ventilation mainly followed the existing duct routes. When a whole block was ready, the external facades were cladded with natural slates, and the gardens were filled and redone. All front gardens were redesigned based on three optional garden designs. Tenants could stay in their houses throughout the renovation. However in addition a few spare houses were reserved for those tenants who preferred to stay elsewhere during the physical renovation work at the main renovation day.

Figure 16: The renovation process continued as a train through the area: 4 houses in a week

Figure 17: The gap between façade and roof element was filled in situ

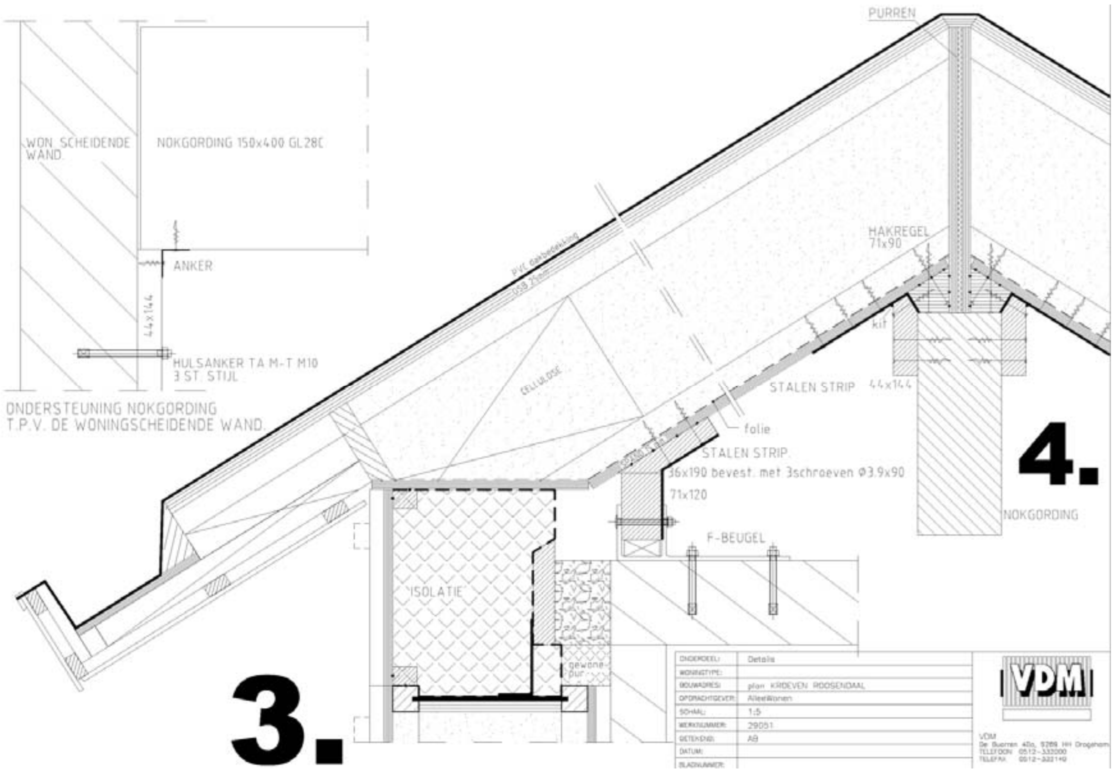

Figure 18: Working detail roof and façade connection

Figure 19: Left: condensing gas boiler before renovation; Right: the new compact system includes a mechanical heat recovery unit, a condensing gas boiler, and a storage tank – connected to the solar collectors.

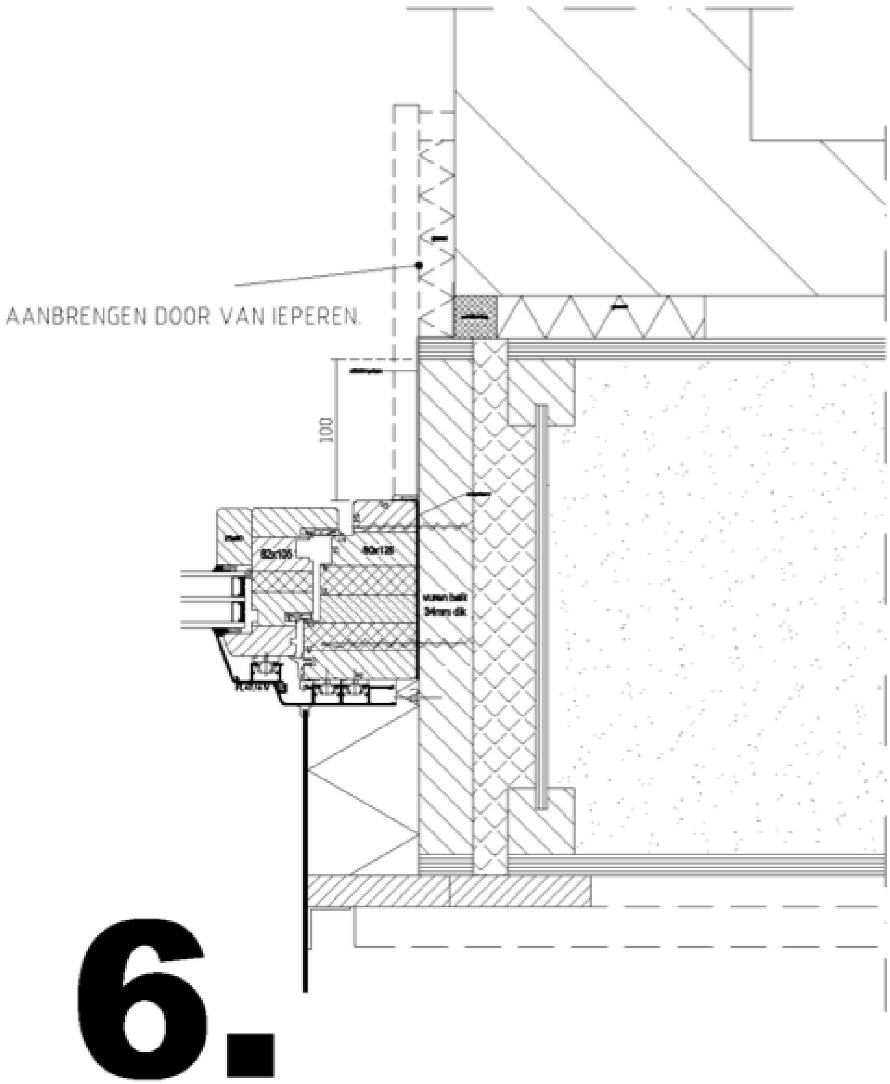

Figure 20: Working detail window placement in the factory and in situ completion works

Tenants have been instructed on how to live in the renovated house. A written guide and a DVD video showing the use of components of the house were made for each tenant. The video explains how to heat and ventilate the building; how to use the ventilation system and how and when to operate the windows in winter, and summer days and nights.

Figure 21: External façade cladding works for a completed block of houses

Figure 22: Detail of façade cladding with natural slates, which was chosen by the architect

Aramis AlleeWonen has made a major effort to manage this advanced renovation at large scale. The investment level for the renovation works is around € 97,500 incl VAT. Redesign and investment in the urban environment are on top of this. In the long run, over the extended exploitation period, income will be sufficient to carry the investment. One way of looking at it is acknowledging that the investment costs are € 25 – 30K higher than a similar renovation would have cost using standard renovation measures. Another way is to learn that the costs of new houses in the same area at the same time, cost 30% more than the passive renovation, whereas rent levels for the new homes are significantly higher than for the renovated houses, including the rent increase that was agreed to compensate for the investment in energy efficiency. Therefore the overall conclusion is that passive energy renovation is suitable to maintain affordable costs of living. However the availability of investment resources limits the replication of the same solutions in multiple projects. Further cost reductions are necessary to boost this solution. A detailed analysis of the costs has been made in WP3.

The process to manage two large passive house renovation projects, and around 100 new passive homes at the same time has been rather intensive for Aramis AlleeWonen. The lesson to be learned from this is to divide such scheme in substreams to spread the efforts of the social housing landlord.

The project was initiated and designed before the E2ReBuild project started. The renovation works were carried out in 2010. After the renovation works subsequent works in the area took place, such as new construction of two apartment buildings, patio houses and single family houses. All public areas such as streets, parks and private front gardens have been redone.

Figure 23: Also the public side of the houses has been redone, by providing designed front gardens.

Figure 24: In the period 2011 – 2013 new construction took place in the same area, which was also passive houses, designed in the same style as the renovation houses.

In 2012 the monitoring programme has been defined, and executed for a two years period. The calendar year 2013 has been used for the monitoring and the analysis in work package 5. Monitoring however continues in 2014, whilst a few alternative settings will be tested.

	From	To
Brief	January 2007	May 2007
Design	June 2007	July 2009
Construction	January 2010	December 2010
Monitoring	January 2013	June 2014

Table 1 Time frame for demonstrator

The key players that were involved in the retrofitting project can be found in the table below.

Role	Name	Brief	Design	Construction	Monitoring
Building owner	AlleeWonen	X	X	X	X
Architect	DAT architecten		X		
Energy specialist	Trecodome		X	X	X
Structural engineer	VDM Woningen bv		X		
HVAC engineer	Dubourgraaf		X	X	
Contractor	VDM Woningen bv			X	
Contractor	Van Ieperen bv			X	
Contractor	Brink Climate Systems			X	
University	TU Eindhoven		X		X
other	Nederlandse Woonbond		X		

Table 2 Key players involved in the retrofitting demonstrator

4 Results

4.1 Conclusions and Experiences

Prefabrication of façade and roof elements has been used as the main means of renovation, with the aim of reducing the disturbance of tenants, constant and high quality and good energy performance. The renovation approach includes much better insulation than current practice via the labelling system in the Netherlands requires. Healthy and comfortable indoor climate conditions have been achieved by the installation of controlled mechanical ventilation with heat recovery. Airflows have been selected with the objective to have such a ventilation rate that the internal CO2 emission level is well below the requirements for new homes.

			Before	E2ReBuild
Facade/wall	U	W/m^2K	0.8	0,11
Roof	U	W/m^2K	2	0,1
Ground floor	U	W/m^2K	2	0,2
Windows	U	W/m^2K	2.4	0,79
Glazing	U	W/m^2K	4	0,5
Average	U	W/m^2K	2	0,22
Ventilation rate		air changes/h	1	0,62

Table 3: U values before and after renovation

The renovation process was special because it allowed a systematic preparation and an on-site implementation whilst the tenants could stay in their homes. The approach has been tested on a pilot renovation house, and was afterwards implemented as a large scale process. Once the renovation was up to speed four houses were renovated in one week. On one day the existing roof and windows were replaced by the new prefabricated roof and façade elements. Each day one truck load for one house arrived on site, and was mounted on the same day. The preparation and completion works have been more intrusive than the renovation itself.

The energy performance is as expected. Gas heating consumption for space heating, hot water and cooking reduced by 65 %. Given that cooking is constant, and hot water reduced by 50 % because of the solar thermal system, the space heat reduction is 75 - 80 %.

Energy savings have been ensured by the landlord in such way that it was guaranteed that the result of rent increase of € 65 per month would not exceed the value of the energy savings in the first five years. Less than 10 % of the tenants made use of the guarantee. These were the tenants who accepted very low indoor temperatures before renovation, and thus had smaller savings than on average.

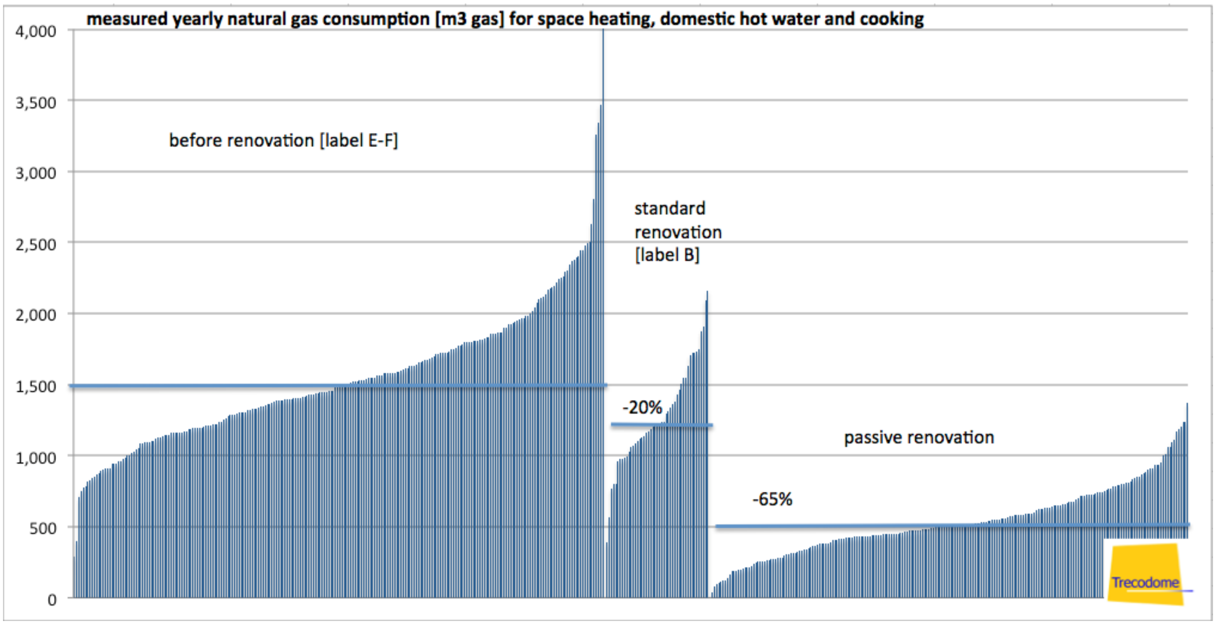

Figure 25: Real energy figures before and after renovation, derived from anonymous energy data of the full area, compared with real data from a similar standard renovation project

Foundation insulation is a rather intrusive process. Also because of existing infrastructure such as gas, water, electricity and sewage pipes it is hard to consider a generic prefabricated solution. The ground works and foundation preparation happened in the weeks before the TES renovation.

Level of the TES element compared to the ground level. The existing external brick layer has been demolished, so that the existing foundation could be used for the new TES element. The existing foundation has been extended with concrete and external EPS insulation. A timber beam has been mounted at zero level to bear the load of the TES element. A gravel box with drainage has been installed in front of this structure to keep the timber beam dry.

What to do with the cavity between the inner brick leaf and the new TES element? In Roosendaal it was decided to seal around windows and door openings. To ensure that no uncontrolled air leakages take place in future projects, the cavity will be filled with insulation.

Because of uncertainty about the accurate sizes of the houses, the roof and façade element have been designed in such a way that an on-site infill was needed to connect the two elements. Today’s current technology of digital scanning allows detailing with immediate connection between roof and façade elements.

The tiling works of the external façade have been done as an on-site activity, since such system cannot be pre-installed in a factory and transported. These works happened in the weeks after the installation of the prefabricated elements. Other cladding solutions allow further prefabrication and thus a faster project execution

The landlord has made significant investments at the level of € 97,500 including VAT which will pay off during the extended exploitation period of 40- 50 years which would not have been the case if the houses were replaced with more expensive new homes. Also the rent increase partially contributes through the pay back. Because of the passive energy renovation the homes remain affordable in terms of rent and energy costs, and indoor climate conditions are very good. The main drawback is the initial investment, though in life cycle terms the exploitation of passively renovated homes is good.

If the renovation costs of such renovation decrease there will be a market for the demonstrated solution.

The houses and the urban environment have changed. The negative spiral in the area because of lack of the monotonous look, lack of maintenance of houses and urban areas has stopped. The intervention by major renovation, strategic demolition and new construction of different house types, and changing the urban spaces has resulted in a positive image of the area.

4.2 Replication Potential

Replication potential is large provided that further industrialisation, product development and implementation scale result in affordable investment costs. Findings from this project have already motivated suppliers from industry to launch products along these lines.

A drawback in the Dutch market is the scale of the national energy labelling scheme. In The Netherlands much less energy efficient schemes than demonstrated here are entitled to be A or B-rated. Real energy efficient renovations are not encouraged because of the chosen calculation method behind in which it is not possible to calculate and to value a passive house renovation scheme. Real energy performance figures though indicate that much better energy performance levels than referred to in the Dutch A and B rating are needed to achieve affordable heating bills and desired CO_2 emission levels.

There is a huge market at the scale of 2 million homes just in social housing sector in The Netherlands which can benefit from this approach, not to speak of the huge European application market, which is there once investment mechanisms aimed at integrated renovation methods are available.

Appendix A Original BEST Sheet

Building Energy Specification Table (BEST)

Community / site	Roosendaal	Kroeven	BEST no. 6
total area / category / BEST sheet [2]	5320 m²		

1,1 Building Category: residential retrofitted — [1] single family housing, built 1963

1,2 Local Climate

Climatic Zone (national definition)	North-West European Sea Climate / zeeklimaat		
January average outside temperature		°C	2,8
August average outside temperature		°C	17,2
Average global horizontal radiation		kWh/m² yr	1000
Annual heating degree days [3]		°Cd/yr	3075

1,3 Maximum requirements of building fabric

			Existing building [5]	National regulation for new built [6]	suggested specification [7]	Energy savings [%] [8]
Façade/wall	U	W / m2K	0,8	0,4	0,1	75%
Roof	U	W / m2K	2	0,4	0,1	75%
Ground floor	U	W / m2K	2	0,4	0,1	75%
Glazing	U_g	W / m2K	4	4,2	0,6	86%
Average U-value	U_{av}	W / m2K	2	1	0,2	80%
Glazing	g	total solar energy transmittance of glazing [%]	0,7	0,7	0,6	14%
Shading	Fs	Shading correction factor				
Ventilation rate [4]		air changes/hr	1	0,5	0,5	0%

2 Building Energy Performance

2,1 Energy demand per m2 of total used conditioned floor area (kWh / m2yr) incl. system losses

energy carrier existing	suggested energy carrier		specify energy efficiency measures [13]	Existing building [5]	regulation / normal practice for new built	suggested specification [7]	% Energy savings [8]
Heating + ventilation							
gas	gas + solar	kWh/m²yr	passive insulation, heat recovery	150	100	25	75%
Cooling + ventilation							
N.A.	N.A.	kWh/m²yr					
Ventilation (if separate from heating/cooling)							
		kWh/m²yr					
Lighting							
	electricity	kWh/m²yr	energy efficient lighting	7	7	5	
Domestic Hot Water (DHW)							
gas	gas+solar	kWh/m²yr	compact vent+solar+backup system	30	30	30	0%
Other energy demand							
		kWh/m²yr					
		kWh/m²yr	Subtotal sum of energy demand	187	137	60	56%
Appliances (please indicate, but costs are not eligible)							
	electricity	kWh/m²yr		30	30	25	

2,2 RES contribution per m2 of total used conditioned area (kWh / m2 yr)

total production kWh/yr	m² installed	kW installed	specify RES measures	Existing building [5]	National regulation / normal practice	suggested specification [7]	RES contribution [%][8]
1500	4 m2		solar thermal system + 200 liter storage	0	0	15	
		kWh/m²yr	Subtotal sum of RES contribution	0	0	15	25%

3 Building Energy Use — per m² of total used/heated floor area (kWh/m2 yr)

kWh/m²yr	Subtotal sum of energy demand	187	137	60	56%
kWh/m²yr	Subtotal sum of RES contribution	0	0	15	
kWh/m²yr	Total Building Energy Use	187	137	45	67%

4 Other national overall energy performance targets or criteria (additional information, mandatory if existing)

	Units [9]	explain content and scale [10]	Existing building	National regulation for new built (2006)*	suggested specification
	label	Energy certificate	F	A	A++
	kWh/m2	Passiefbouwenkeur	150	60	25

Appendix B Energy Data

Roosendaal Before			Calibrated calculation in PHPP			
	Energy Demand Before [kWh/m2 NFA]	Source	PE conv. fact. fp [kWh PE / kWh S] national /local	PE national [kWh/m2 NFA]	PE conv. fact. fp [kWh PE / kWh S] acc. EN 15603	PE based on EN 15603 fp [kWh/m2 NFA]
Heating Source 1	95	Gas	1	95	1,36	129
Heating Source 2				0		0
DHW Source 1	24	Gas	1	24	1,36	33
DHW Source 2				0	0	0
Auxiliary	1	Electricity	2,6	3	3,31	3
Losses Source 1	9,5	Gas		0	1,36	13
Losses Source 2	7,2	Gas		0	1,36	10
Total	**136,7**			**122**		**188**
Delivered to the grid			0	0		0

Roosendaal Afterwards			Calculation in PHPP			
	Energy Demand Afterwards [kWh/m2 NFA]	Source	PE conv. fact. fp [kWh PE / kWh S] national /local	PE national [kWh/m2 NFA]	PE conv. fact. fp [kWh PE / kWh S] acc. EN 15603	PE based on EN 15603 fp [kWh/m2 NFA]
Heating Source 1	22	Gas	1	22	1,36	30
Heating Source 2				0		0
DHW Source 1	12	Gas + Solar ther	1	12	1,36	16
DHW Source 2			0	0	0	0
Auxiliary	3,5	Electricity	2,6	9	3,31	12
Losses Source 1	2	Gas	1	2	1,36	3
Losses Source 2	3,6	Gas	1	4	1,36	5
Total	**43,1**			**49**		**65**
Delivered to the grid			0	0		0

Conversion factors fp (total) acc. EN 15603:2008* Table E1 - Annex E		
Electricity (UCTE Mix)	3,31	[kWh PE / kWh S]
Natural gas	1,36	[kWh PE / kWh S]
Reference national conversion factors:	**NEN7120**	