Deliverable Proof – Reports resulting from the finalisation of a project task, work package, project stage, project as a whole - EIT-BP2018

Name of KIC project the report results from that contributed to/ resulted in the deliverable	2nd SKIN SCALER KAVA 4.2.7.BTA Flagship Scaler – 2ndSKIN Deliverable: 4.2.7 2ndSKIN D3 Project Performance Report
Name of report	Project Performance Report 2018
Summary/brief description of report	This report contains the 2ndSKIN Performance Reporting for 2018. It consists of two parts; . Part 1 Reprint of the Performance Report from PLAZA . Part 2 A more extended and illustrated report on the achievements and work implemented within the 2ndSKIN SCALER project in 2018.
Date of report	20 December 2018

Supporting Documents: attach in pdf format

Climate-KIC is supported by the EIT, a body of the European Union

2ndskin

2ndSKIN SCALER
EIT Climate-KIC

Project Performance Report 2018

(deliverable 4.2.7 2ndSKIN D3 Project Performance Report)

eit Climate-KIC

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

Preface

This is the performance report 2018 of the 2ndSKIN SCALER project.

It is an update on the project results and progress during 2018. The end of the project is planned for 31 March 2019.

The report is built up in two parts:

1. A reprint of the Performance Report from the PLAZA for a global overview of the progress in 2018
2. A more extended and illustrated report on the achievements and work implemented within the 2ndSKIN SCALER project in 2018.

I'm very proud of the result of the SCALER. A new 2ndSKIN Zero Energy READY was developed and applied in 183 apartments in Vlaardingen. Considerable cost reductions resulted in a market ready solution, a stepping stone solution enabling an easy upgrade towards full Zero Energy apartments in the future.

Reaching this point hadn't been possible with the enormous support of many people.

We would like to thank Waterweg Wonen for offering us another possibility to up-scale the 2ndSKIN concept in Vlaardingen. Without an innovative and cooperative client like Waterweg Wonen, projects like this are impossible to execute and to learn from.

We are grateful for getting so much and stimulating support of EIT Climate-KIC staff.

Also in this SCALER project we could rely on the support of very renowned industrial partners like STO, Kingspan, ITHO/Daalderop and their preferred installers like Giesbers Installation Group. Having these companies and their networks partnering is of great value.

Furthermore I very much appreciate the cooperation with the very professional and experienced team of BIK Bouw; Onno de Wal, Jasper Sluimer, Elles de Wal, and many, many others.

Working together on the 2ndSKIN development, I'm very happy and thankful to work on the scientific challenge around 2ndSKIN with my TU Delft colleagues Stella Boess, René van Egmond, Thaleia Konstantinou, Tillmann Klein, Juan Azcarate Aguerre, the TU München colleagues Thomas Auer, Lukas Lauss, David Selje and Tobias Wagner and the Office Vitae team, David Keyson, Tako Werts & Marc de Hoogh.

Last but not least we couldn't have done this project without cooperation, input, remarks and hospitality of the families of the complex at the Indische Buurt in Vlaardingen. We realise that they were exposed to a lot of inconveniences. We thank the families withstanding the renovation activities and hope they will experience and enjoy the advantages of it for a long time.

Sacha Silvester
December 2018

2ndSKIN SCALER EIT Climate-KIC

Project Performance Report 2018

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Part 1 Reprint PPR18 from PLAZA

Part 2 illustrated Performance Report

Pre-renovation situation above and renovated apartments below 'Indische Buurt' Vlaardingen, The Netherlands




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Summary

TU Delft , BIK Bouw, TU München, Office Vitae in cooperation with Waterweg Wonen Housing, STO Isoned, ITHO Daalderop, Giesbers van der Graaff and Kingspan with the support of EIT Climate-KIC work together to realize a SCALER project on Zero Energy (ZE) READY Renovation in Vlaardingen, the Netherlands. As a result of this SCALER Project, 183 homes are refurbished to become Zero Energy READY Buildings. 'Zero Energy READY Buildings' means that the housing complex are high-energy efficiently renovated (label A+) and can be upgraded to become Full Zero Energy in future by replacing the installations after their end-of-life in about 10 to 12 twelve years.

The package of this 2ndSKIN product-/service solution differs from the package that is applied in the 2ndSKIN DEMONSTRATOR. The costs of this solution are too high, compared to the budgets the housing associations are able to make available in large scale renovation project. The ZE READY package is an optimised balance between high energy performance and investment costs for the present-day Dutch market. The costs per apartment of the ZE READY (k€ 35, 2018) are 45% of the costs of the Full ZE (k€ 78, 2017) and the CO2-reduction is 73% of that of the Full ZE solution. The renovation of the 183 ZE READY apartments will be finished in Q1 of 2019.

Besides the ZE READY solution, the Full ZE is under development to become more cost efficient. New, more simple installation concepts are being tested and validated, at first in the lab and in Q1 of 2019 in three apartments of the SCALER-project in Vlaardingen. Furthermore a roadmap is formulated to improve the value chain integration and the financial performance that should lead the consortium to the profound cost reduction needed for the large-scale implementation of the Full ZE 2ndSKIN solution.

During 2018 a coherent user acceptance process that would ensure efficiency was conceptualised as streamlining and standardising the process for the largest group, thus freeing up resources for a smaller number of residents that needed support. The acceptance rate by the residents for the SCALER project was very high again.

Monitoring of apartments of the DEMONSTRATOR project continued throughout the year. From the SCALER project a sample of 11 apartment is intensively monitored for comparison. Aside from the monitoring, all consortium members also regularly visit the residents in their homes. TU Delft is conducting qualitative research into the residents' home practices and satisfaction with their home.

Indoor temperature is much more even after the renovation than before, although still fairly warm in the summer. The residents are happy with the improvement. In the winter, the heating installation has sometimes had trouble reaching higher than 21° Celsius indoor temperature.

Indoor CO2 is much lower after the renovation than before, so the renovation was successful in this regard, as well.

The DEMONSTRATOR project boosted the knowledge sharing and transfer of the 2ndSKIN approach. One of the apartments was used as information centre for more than three months in 2018 and attracted a lot of attention from the different national and international stakeholders. Targeted communication through social and traditional media delivered concrete leads for potential next projects.

The 2ndSKIN upscaling was focussed on the Dutch Social Housing market. Social housing organisations are appointed by Dutch politicians as lead market for ZE renovation. In Q1 of 2019 plans for targeting the European Market will be further fine-tuned together with the EIT-Climate-KIC.

1. Introduction

Context

The context of the 2ndSKIN zero-energy renovation approach is formulated before as follows. "*Being one of the biggest energy users, the residential building stock needs to be upgraded in order to improve performance, reduce energy demand and eventually reach the ambitious energy and decarbonisation targets for 2020 and 2050 that require an eventual reduction up to 90% in building sector related CO_2 emissions. This reduction is larger than in other sectors such as transportation, agriculture and industry, indicating the importance of the building sector and the urgency of the measures to be taken. In order to achieve this significant reduction, the recast of the EPBD in 2010 suggests that new buildings should be low- or zero-energy buildings ((DIRECTIVE 2010/31/EU). As a greater challenge, however, the European Commission (2011) stated the refurbishment of the existing buildings, suggesting that over the coming decade investments in energy-saving building components and equipment will need to be increased by up to € 200 billion. While new buildings can be constructed with high energy performance levels, the existing stock is predominantly of poor energy performance and consequently in need of renovation work.*

In this context, the depth of refurbishment needs to grow. Superficial renovations, as opposed to deep renovation, significantly increase the risk to miss the climate targets and leave huge absolute savings untapped"(Silvester 2017).

Since the start of the 2ndSKIN project the urgency to speed-up the the deep renovation has dramatically increased. The recent IPPC report (IPPC 2018) and the 2018 Katowice United Nation Conference on Climate Change are calling for intensifying measures like deep renovation for our built environment.

The Netherlands forms a challenging innovation context for deep renovation. Although the overall EU-ranking on CO_2 reduction of the Netherlands is pretty low, the ambitions are higher than EU policy goals. The Dutch Parliament agreed upon a Climate Law thru which the goals of a reduction of 55% on Green House Gas Emissions in 2030 and a reduction of 95% in 2050 are safeguarded (Tweede-Kamer 2018). Within the built environment environment the social housing stock is being selected to play a lead user role in the upscaling of deep renovation concepts.

As discussed with the EIT Climate-KIC Urban Transition & Building Technology Accelerator Staff and based on the mentioned developments it is decided to focus the SCALER first on the Dutch Market to create volume and avoid the scattering of resources over a lot of different European projects. However during the development of the 2ndSKIN approach the broader EU-feasibility is being validated in dialogue with partners in Germany and Spain and thru international academic discussions.

Aim and project description

The 2ndSKIN-approach is developed in the Netherlands. Knowledge, insights and experiences from experiments, demonstration- and research projects in Europe are used to define a product-/service combination that is being demonstrated in Vlaardingen. The net zero energy renovation of 12 apartment units in the social housing estate of Waterweg Wonen was developed, planned, built and monitored in 2017 (Silvester 2017).

The SCALER project builds on the lessons learnt and the experiences gained during that -EIT Climate-KIC subsidised- DEMONSTRATOR project.

The aim of the 2ndSKIN SCALER project is:

- Making 2ndSKIN an affordable and attractive Zero-Energy-Renovation solution for large-scale market introduction in the social housing market in Europe. By:
  - Optimized and tested Nett-Zero-Energy Ready renovation proposition for the N=183 apartments of Waterweg Wonen in Vlaardingen fitted for the present-day market. This large project will serve as a case for deciding the optimum for investments versus CO_2/sustainability impact.
  - A small number of dwellings will be reserved from the total stock to prepare the next steps in the roadmap towards large scale implementation based firstly on the results from the Demonstrator Project and secondly on the findings of the larger project of N=183.
- Define and start executing, together with the industrial partners Kingspan, STO, ITHO Daalderop & BIK Bouw in close cooperation with EIT Climate-KIC, an ambitious business plan for up-scaling the 2ndSKIN approach, starting in the Netherlands to be followed by a strategic diffusion plan for Europe, based on the experiences with the DEMONSTRATOR and SCALER projects in Vlaardingen.

This report gives an overview of the activities and results of the 2ndSKIN SCALER project which took place in 2018. The 12-months lasting SCALER will finish the 31st of March 2019. The consecutive chapters will describe the technical development (WP2), the user acceptance & monitoring (WP3), the business & service validation (WP4), knowledge sharing & transfer (WP5), conclusions.

left/ back side after, right/ during renovation (part of the N=183 apartments)

2. Technological Development (WP2)

Introduction

After the DEMONSTRATOR project that resulted in the renovation of 12 apartment to zero energy level, the SCALER project follows, which aims at the renovation of 183 apartments. The apartment types of both projects are located in the same district and they have the same layout and construction details, following the SIMPLEX system (Priemus and Elk 1971). However, in the SCALER project phase, the objective was not a zero-energy performance. Due to a lower budget per dwelling, the housing association did not attempt to achieve a zero-energy renovation but rather a zero-energy-ready (ZE-ready) renovation which improves

Table 1 Overview technical options of the DEMONSTRATOR & SCALER solutions

		Demonstrator	Scaler	Explanation
Façade	Wall	rigid expanded polystyrene, by STO Plaster finishing U 0,16 W/Km2, Rc 6.0	rigid expanded polystyrene, by STO Brick veneer (steenstrips) U 0,16 W/Km2, Rc=6.0	The wall structure is in both phases identical, except for the outside cladding: plaster (demonstrator) and brick veneer (scaler)
	Windows	u-PVC frames Triple glazed panes Uw 1 gg o,8	u-PVC frames Double glazed panes	Because of budget reasons, the client chose to use double-glazed panes, instead of triple glazed.
	Roof	insulated panels, by Kingspan U 0,14 W/Km2 (Rc 7,0)	insulated panels, Unidek Reno Dekfolie RC 6.0, by Kingspan U 0,14 W/Km2 (Rc 7,0)	Because of budget reasons, the client chose to use these insulated panels.
	Basement	expanded polystyrene in granulated form blown crawling space U 0,28 W/Km2 (Rc 3.5)	expanded polystyrene in granulated form blown in crawling space U 0,28 W/Km2 (Rc 3.5)	This solution was proved to be the best solution during Demonstrator, so it didn't have to change in the Scaler phase.
	Balcony	remove and replace	Existing Balconies, new balustrade	Because of budget reasons, the client chose for this new option.
	Entrance	New closed entrance	New closed entrance (under construction)	Because of budget reasons, the client chose for this new option.
Services	Ventilation	mechanical ventilation with heat recovery, up to 95%,	Natural inlet through window trickle vents, CO2 sensor, outlet Climarad mini box, bath and kitchen	Because of budget reasons, the client chose for this new option.
	Heating	Ground-to-water heat-pump COP 6.00	Gas	Gas was financially a more appealing solution, so the client chose this option.
	DHW	Ground-to-water heat-pump COP 3.00, 200 l Boiler	Gas	Gas was financially a more appealing solution, so the client chose this option.
	PV	PV capacity of 300 Wp /panel, 15 panels per home	PV capacity of 300 Wp/panel, 5 panels per home	Because of budget reasons, the client chose for this new option.

the dwellings to energy label A+. Additional measures can be taken in the future to bring the building to zero-energy.

Evaluation of the previous solution

The 2ndSkin DEMONSTRATOR project phase concluded in an innovative solution for net zero-energy apartments. The lessons learned during this project are three-fold: the technical solution, including building envelop and services upgrade; the occupants' acceptance process; and the performance guarantee. The renovation resulted in excellent insulation and airtightness, featuring external insulation on the walls, new window frames with triple gazing and new, prefabricated insulated roof panels, which are fully covered with photovoltaic panels. As suggested by the national energy goals, the building is disconnected from the gas which complies with the current energy policy. The heating and domestic hot water (DHW) is provided by ground-source heat pump with an efficiency of COP6. The heat pump, water tank and heat-recovery ventilation unit are placed in insulated boxes that are located outside the houses on a new, enlarged balcony. The energy calculations show a net energy surplus on an annual basis for standardised occupancy. Those calculations allowed for a 25-year zero-energy performance contract to be agreed between the building services provider and the building owner. According to the contract, the building services provider guarantees the

maintenance of the systems and the energy demand for a fixed amount per dwelling.

Despite the concept being innovative and achieving the zero-energy performance, the cost of this solution remains relevant high, compared to the budgets the housing associations are able to make available in large scale renovation project. The next challenge would be to find the balance between high energy performance and investment costs.

Aim of the SCALER project

The SCALER project aims at using the lessons learned in the DEMONSTRATOR project and scale the concept up for 183 apartments while adapting it to fit the much lower budget. As a result, the large scale renovation is not aiming at zero-energy, but zero-energy-ready. Moreover, the project provides the opportunity to test in few of the apartments the possibilities for additional, innovative interventions that constitute the next step towards Net Zero Energy V2.0.

The measures applied in the SCALER renovation aimed primarily at the high thermal performance of the envelope, and the energy generation with the use of photovoltaic panels. The building services systems were upgraded to more efficient units, but not with the zero-energy objective. Those upgrades are according to the specification required by regulations and still improve the performance significantly, from an average label D to A+. Table 1 presents a comparative overview of the renovation measures.

Building envelope upgrade

The thermal resistance of the opaque parts of the façade was improved with the addition of an external insulation layer. The material used is rigid expanded polystyrene, supplied by STO. The needed insulation thickness, in order to reach the prescribed U-value, is 19 cm. This solution is the same as the Demonstrator. The only difference is that after with insulation is placed on the existing wall, with the use of an adhesive medium, brick stripes were added externally, to preserve the brick façade appearance. The insulation of the crawling space is also the same, as it was proven to be applicable and cost-effective.

More changes can be seen in the solution regarding the roof and the windows. The roof has been insulated with rigid EPS insulation boards and ceramic tiles on top, instead of the prefabricated sandwich panels of the demonstrator. The SCALER solution was easier to apply, as it made the connection between wall and roof easier. The windows are double glazed. Finally, the balconies are not replaced, which provides considerable savings in the investment of the new balcony construction.

Building services upgrade

The ambition for the 183 apartments was zero-energy ready, with the investment cost kept at more than half of the DEMONSTRATOR cost. The building envelope thermal properties upgrade explained above are very similar to the previous concept and deliver a high performing shell, as it is considered the first important step in a step-wise approach. As a result, the building services were decided to have an efficiency upgrade, but not changing the energy source to a gas-free solution, as it would be a more costly intervention and would require additional site works. The heating and DHW are provided by a new, high-efficiency gas boiler. The ventilation of the dwelling is implemented by natural inlet through window trickle vents, with CO2 sensors, and mechanical outlet through a mechanical ventilation mini box, placed in the bathroom, kitchen and toilet.

Overview of the technical solution

As explained above, some of the technical options were modified from the Demonstrator project to the Scaler project. The reason for those decisions was

mostly related to budget differences, as well as the different ambition level for the performance.

Evaluation and Further development

Evaluation round tables

The applied technical solution for the building envelope and the services was evaluated in round-tables with the participation of the general contractor BIK Bouw, the building services engineers Giesbers Installation Group and researchers from the TUDelft. The outcome of the discussion was the advantages and disadvantages (Table 2) of the zero energy concept currently applied, which also led to the identification of further developments and new concepts to be evaluated, within the framework of the 2ndSKIN SCALER project.

Round Table on evaluation 2ndSKIN DEMONSTRATOR versus SCALER solution, 8th of October 2018 at TU Delft, Architecture.

Table 2 DEMONSTRATOR Solution advantages & disadvantages

Advantages	Disadvantages
• Performance/ EPV/ zero energy guarantee • People satisfied/good reviews • Summer/winter situation • Good team process • Development of solutions while building • Innovation aspect • Good press • Nice design • Good approach with users • Short engineering time	• High investment cost • Fixing gardens • Too much weather dependent • Too much time inside the house • Clash of disciplines in construction, due to a tight timeline • Complicated user-technology interface • Chance of traditional system • Users do not understand the systems/ need to be explained • Interface acceptance • Component connections • Time intensive acceptance process • Long time monitoring • Oversized and heavy installation for such small apartments

New energy concepts, towards Net Zero Energy V2.0'

The above evaluation of the 2ndSKIN concept concluded to some improvements that can be made to reduce the cost or improve the performance. On the one hand, a "no regret", stepped approach can be a way to reduce the high initial investment costs while achieving the eventually required energy and carbon savings. Studies (BPIE 2011) have shown that a stepwise approach to zero energy buildings has the potential to reach the climate goals for 2050.

In the case of the SCALER 2ndSKIN, the concept applied for the "Zero Energy READY" apartments, which upgrades the envelop thermal properties and introduces energy generation on-site, can be considered as the first step. The next

step will be to upgrade the building services. The energy concept used in the DEMONSTRATOR is an option, but other alternatives can be promising, to achieve the same high performance, with lower cost. The lower cost is related to the cost of the equipment themselves, but also to the space they occupy and their weight. If they are lighter and smaller, additional constructions to accommodate the building service can be reduced or avoided, thus saving in the construction costs.

The options considered include improving the existing DEMONSTRATOR concept, for more space- and energy-efficient heat pumps and water tanks. This improvement needs the collaboration of the units' manufacturers. Moreover, an alternative to heat pump technologies for a gas-free solution, such as electric heating, should be deliberated and calculated for their efficiency. Finally, options to simplify the system, but still get the needed energy savings can be tested. Table 3 presents an overview of the considered options. Subsequently, those options will be simulated by the researchers of the TU Munich to give insights into their performance.

The preferred installation partner *Giesbers & van der Graaff* is testing three alternative innovative solutions for the net zero energy V2.0 at their *Experience Centre* in Schiedam.

The client of the SCALER project - Waterweg Wonen- agreed to dedicate three apartments of complex to serve as test locations for the comparison of the alternative next generation installation concepts. This will be implemented Q1 of 2019.

In deviation from the original 2ndSKIN SCALER proposal, the consortium has chosen to limit prototyping of alternative installations to three apartments instead of twelve. This has been decided because it is very far-reaching in the logistic of the on-going renovation and the associated costs are also considerable. Furthermore, the client - Waterweg Wonen - demands that the operation of these installations is also worthy of a period of 25 years. The imminent follow-up project in Capelle aan de IJssel will probably be used to validate the newly developed facade concepts.

Table 3 Overview of new concepts for building services

Nr.	System Components	Pro	Cons
0	Existing • Gas-boiler • Radiators • DHW-boiler • Natural ventilation	• Low investment costs • Higher system temperatures (compared to heat pump) possible	• Non-renewable energy source • Planned ban on natural gas by 2050 in the Netherlands • Poor efficiency of old gas-boiler • High operating costs
1	Demonstrator • Heat pump • Borehole heat exchanger • Low-temperature radiators • DHW-boiler • Central mechanical ventilation system • Photovoltaic system	• Optimised CO_2 balance (depending on system temperatures and primary energy factor) • Low operating costs and very efficient with low-temperature radiators • Can be retrofitted into old buildings through little effort • Constant heat source temperatures trough borehole • Heating and cooling possible with reversible heat pump • Good air quality	• the High investment costs for geothermal probe • Some space for boreholes required • Efficiency depends on soil (quality) • Approval required • Ventilation: Expensive and high construction work impact
2.1	HPgroundwater • Heat pump • Absorption and extraction well • Radiator • DHW-Tank • Decentralised • Ventilation system with heat recovery • Photovoltaic system	• Optimised CO_2 balance (depending on system temperatures and primary energy factor) • Low operating costs and very efficient with low-temperature radiators • Can be retrofitted in old buildings through little effort • Constant heat source temperatures trough groundwater • Heating and cooling possible with reversible heat pump • Good air quality	• Approval required, as contact with groundwater; strict requirements possible • Efficiency depends on ground water level • Some space for wells necessary
2.2	HPambientAir • Heat pump • Radiator • DHW-Tank • Decentralised ventilation system with heat recovery • Photovoltaic system	• Optimised CO_2 balance – (depending on system temperatures and primary energy factor) • Low operating costs and efficient with low-temperature radiators • Cheapest heat pump system in terms of investment costs • Can be retrofitted in appropriate old buildings through little effort • Heating and cooling possible with reversible heat pump • Good air quality	• Fluctuating efficiency, less economy on cold days • Installation location at the ambient air must be available • The outside unit causes noises, bad for installation near to sleeping room
3	• District Heating • Transfer Station • Radiator • Decentralised ventilation system • Photovoltaic system	• Environmentally friendly, good CO_2 balance (dependent on energy suppliers) • Low investment costs • Space saving, little space needed for technology • Good air quality	• In the annual balance, the prices for district heating are often higher than those for oil or gas (depending on energy suppliers) • Highly price depending on energy suppliers
4	Electrical +HPexhaustAir • Electrical heating panels • Exhaust air system, combined with exhaust heat pump • DHW-Tank • Photovoltaic system	Electrical: • Only small space requirement • Maintenance rarely or not at all necessary • Low investment costs for the heating panels • HPexhaustAir: • Efficient heat recovery • Constant heat source temperatures trough constant extract air temperature	Electrical: • High operating costs due to electricity price • Often no correlate between PV production/heating demand • Bad primary factor electricity • Air pollution by coal-generated electricity • HPexhaustAir: • Maintenance due to regular filter change • Additional investment costs
5.1	100% Electric • Electrical heating panels • Decentralised ventilation system with heat recovery • DHW-Tank • Heating rod • Photovoltaic system	• Annual energy: possible to reach zero energy (with a high number of PV modules) • Only small space requirement • Maintenance rarely or not at all necessary • Low investment costs for the whole system • Good air quality	• High operating costs due to electricity price • Often no correlate between PV production/heating demand • Bad primary factor electricity • Air pollution by coal-generated electricity
5.2	100 % Eletrical +BatteryStorage • Electrical heating panels • Decentralised ventilation system with heat recovery • DHW-Tank • Heating rod • Photovoltaic system • Battery storage	Electrical: • Only small space requirement • Maintenance rarely or not at all necessary • Battery storage: • Production of electricity by PV compliant with electricity consumption • More control and independence from the electricity supplier • Improve the eco-balance of electrical heating	Electrical: • High operating costs due to electricity price • Electricity generation (still) pollutes the environment • Battery storage: • No long-term experience available • Long planning necessary • High investment costs

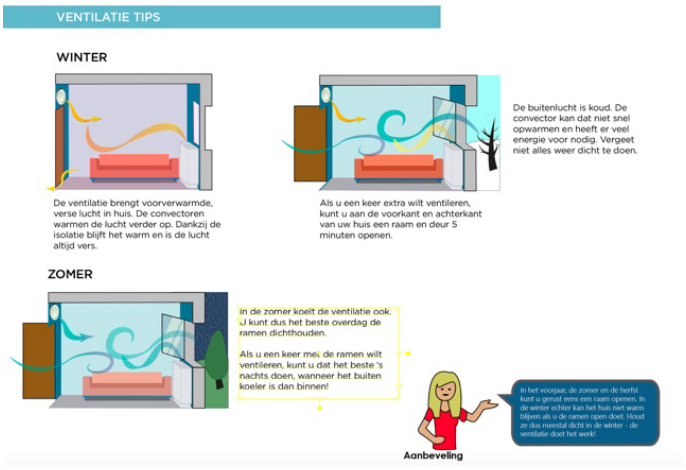
3. User Acceptance & Monitoring (WP3)

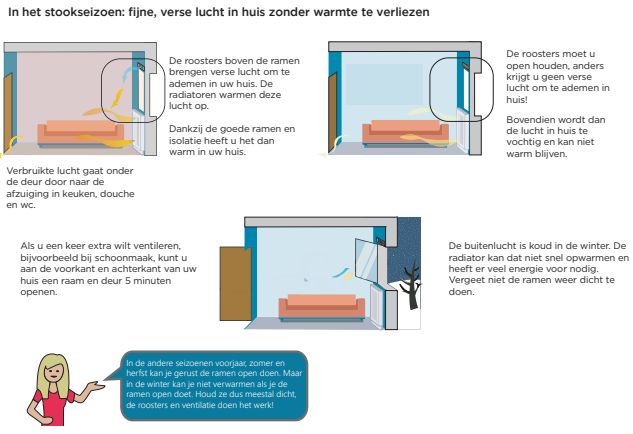
Acceptance

The user-approach (communication, user-involvement, feedback) in the 2ndSKIN DEMONSTRATOR resulted in an exceptionally high tenant acceptance rate of 100%. This was achieved by acknowledging tenants' desire to stay put, while building trust in 2ndSKIN's improvement of indoor climate: from tough and damp to stable and healthy. What still needed to be evaluated is whether 2ndSKIN enables tenants to live 'ZE' post-renovation.

The user approach in the DEMONSTRATOR was highly personalised and developed many new tools from scratch and needed to become more time- (and cost-) efficient for the large-scale implementation.

During 2018 a coherent user acceptance process that would ensure efficiency was conceptualised as streamlining and standardising the process for the largest group, thus freeing up resources for a smaller number of residents that needed support. To ensure this support, BIK Bouw practiced *sustained listening* and *bridging* of any issues that were seen in both N=12 of the DEMONSTRATOR and N=183 of the SCALER projects (Boess, Silvester et al. 2018). Such issues required, for example, close cooperation with both the client, local social services and in one instance the police, but also, helping residents change energy providers. Besides these two components, the process should comprise *demonstrating* home interactions with the new technologies, favouring direct interaction and **visual communication** over text-based materials in order to include all residents, and *eliciting* resident needs in structured and customized ways. A software solution was evaluated positively that serves to inform residents in their preferred ways as well as keeping track of those residents that require more intensive interactions as mentioned above. For the N=183 apartments of the SCALER, a comparison study was set up in which half of residents received an extra visual component in addition to the manual, and half did not. The results of this study are still pending.

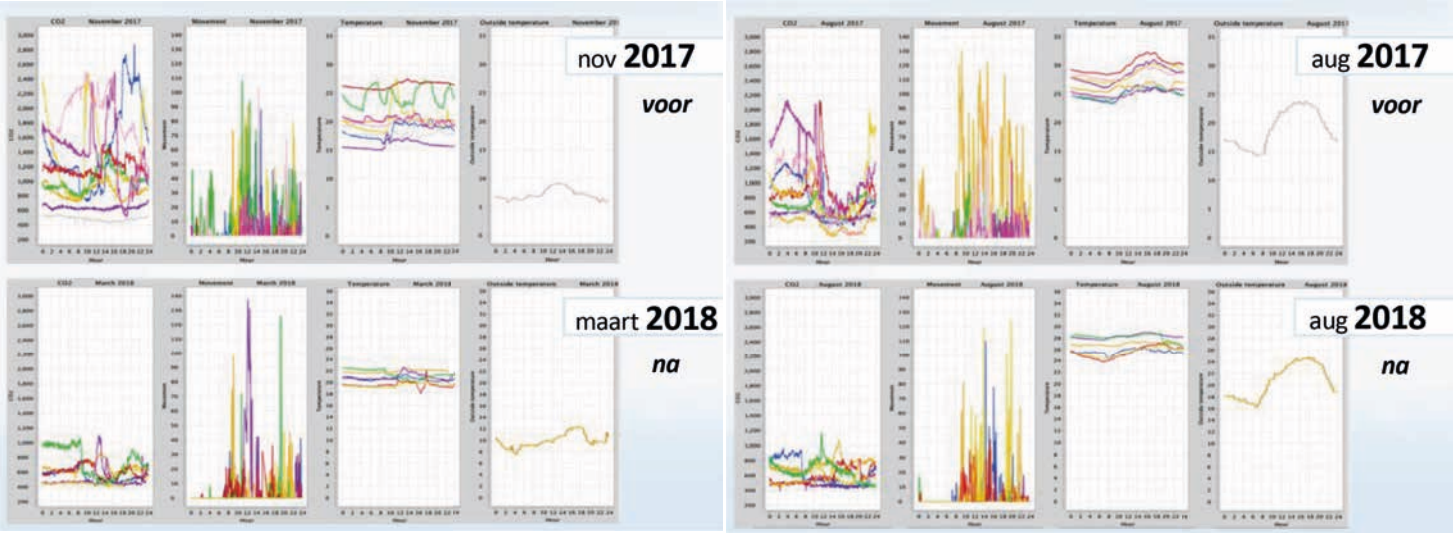




Example of research material for testing the effects of different ventilation instructions.

Monitoring

Monitoring of apartments of the DEMONSTRATOR continued throughout the year. Of the 12 apartments, 10 are being monitored. One apartment was vacant during much of the year, and in another apartment, the resident declined to host the sensors. Aside from the monitoring, all consortium members also regularly visit the residents in their homes. TU Delft is conducting qualitative research into the residents' home practices and satisfaction with their home. While statistical overviews are still being created, some point measures can be presented here that directly compare selected similar outdoor climate Sundays before and after the renovation. Indoor climate on these days can be compared because the outside temperature, and its progression during the day, was similar. Moreover, there was movement in all homes, indicating presence in the home. Each coloured line



Example Indoor climate data on a cool day (left) and warm day (right) before (top) and after the ZE-renovation (bottom) in DEMONSTRATOR project

represents one room in one home, being measured over the course of the selected day. The figures show that CO2 fluctuated wildly and reached levels of over 2000 ppm momentarily during the selected cool and warm days before the renovation. After the renovation, the CO2 levels had calmed down markedly on both cool and warm days and hardly ever exceeded 1000 ppm anymore.

As preliminary conclusions we can state that

- Indoor temperature is much more even after the renovation than before, although still fairly warm in the summer. The residents are happy with the improvement. In the winter, the heating installation has sometimes had trouble reaching higher than 21 degrees indoor temperature. Although the envisaged norm temperature for a ZE dwelling is 20 degrees, in practice some of the residents experience this as too cool and would like it to be higher. This is due, according to these residents who would prefer more warmth, to their higher age and health issues, and in another dwelling, to their having a small child.
- Indoor CO2 is much lower after the renovation than before, so the renovation was successful in this regard, as well. However, there are still sometimes peaks in some rooms, although these are much fewer and lower than before the renovation.

An issue that was being noted through regular visits with the residents was that the new combination of technologies being implemented to contribute to the ZE outcome was difficult for both professionals and residents to conceptualize.

Consortium partners commented that normally, the manuals from installation companies can be collected and combined in order to produce a new manual for a home. In the N=12 case, however, the new combination required new steps in integrating user instructions too. This led to a new approach in compiling the user manual. Although the same complexity did not apply to the N=183 because of the more conventional combination of technologies, here too a new approach was adopted. This resulted in manuals in a more visual communication approach, as shown above.

In the N=183 SCALER project, 11 households could be recruited for in-depth monitoring via indoor climate sensor boxes, interviews and observations in order to allow for direct comparison with the N=10 households of the DEMONSTRATOR project . New sensor boxes were employed here. These boxes are smaller and more robust than the boxes used in the DEMONSTRATOR. No data aggregations are available yet, because the sensor boxes could only installed in late summer or autumn 2018.

Besides this monitoring, detailed assessment of the energy is taking place in both DEMONSTRATOR as SCALER projects. The post renovation period of the DEMONSTRATOR project is still too short, because start-up issues with the installations and time for the residents to get used with the new installations, to generate sound conclusions about the actual energy balance of the apartments.

The SCALER project is in its final stage of the renovation process, after which also there the energy assessment will start taking place.

4. Business & Service Validation (WP4)

Introduction- Previous recommendation

The 2ndSKIN energy retrofitting strategy aims to provide a technological and organisational solution to the problem of systemic underinvestment in deep residential energy renovations across the Netherlands and the EU. It aims to support the decision-making process of institutional residential real estate operators, particularly in the social housing sector, towards (near) zero-energy renovation measures.

The previous "DEMONSTRATOR" project phase recognised the currently limited commercial uptake of a full zero-energy renovation due to the high initial investment cost in relation to the target buildings' property value. A situation which particularly hinders the social housing market, as it is defined by lower property values and rental incomes. The project stage arrived at two main strategies, as recommendations, in order to achieve a lower initial investment cost and increase the commercial feasibility of the business model:

A. Economy of Scale

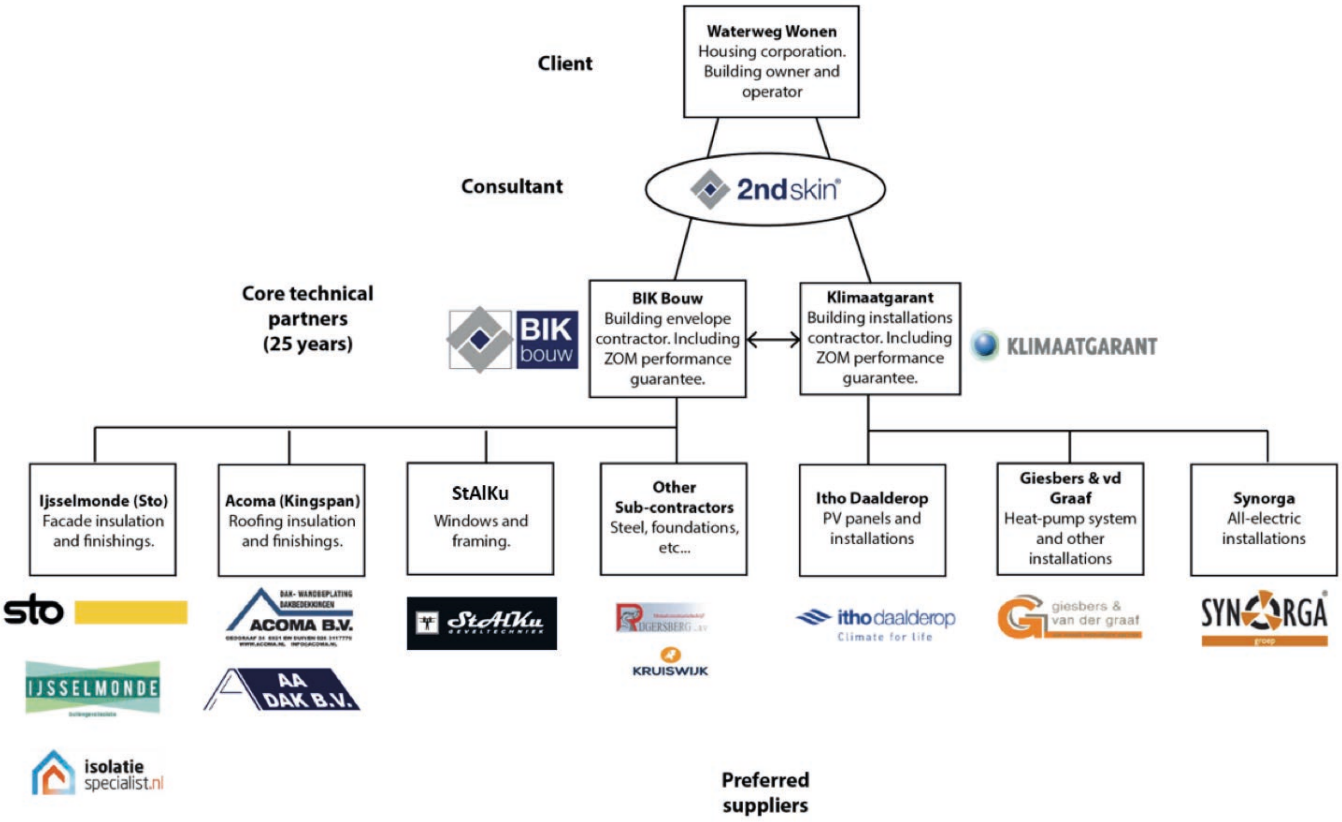
The first source of cost reduction is expected from the simple effect of economy of scale (EoS) for a large-scale project (i.e. above one hundred units). Economy of Scale is the relative reduction in production cost per unit as the number of units produced increases.

Economy of scale estimates were divided into two main categories:

1. Planning and administration costs (P+A): While only representing about 10% to 15% of project costs, P+A expenses are expected to get the largest EoS benefit as design and engineering, logistics, and project management costs are significantly reduced in large projects with higher levels of repetition. Resultant savings per dwelling due to P+A scaling were calculated at approximately 88% of the unitary cost per dwelling.
2. Sourcing and construction costs (S+C): Are expected to decrease by approximately 5% to 15% due to the larger scale of the project, leading to discounted price structures from suppliers and other service partners, as well as larger repetition in construction processes. An industry average of 10% has been used. Overall reduction in costs due to EoS effects on these processes are therefore estimated at 17% per dwelling unitary cost.

B. Supply-chain integration

A second source of potential cost reduction was recognized in a more efficient integration of BIK Bouw's supply chain for both products and services. Simply by reducing or eliminating the safety margins generally found in the construction industry at every supplier tier, savings of between 8% and 20% were calculated. The proposed supply-chain relies on two key stakeholders: BIK Bouw as building envelope contractor, including a Zero Energy performance guarantee; and Klimaatgarant as counterpart responsible for building systems and installations. Both partners would streamline their value chain by taking over risks from their preferred suppliers, improving workflows, and establishing long-term relations, therefore achieving better costs and savings which could be transferred to the client.



Problem statement. Current market conditions.

The current SCALER phase targeted a large-scale renovation of 183 units. Due to a lower subsidy per unit, the housing association did not attempt to achieve a full zero-energy renovation – deeming it financially unfeasible – but rather the best possible renovation with a budget of around 30 k€ per dwelling. As a comparison, the best price achieved by the DEMONSTRATOR phase for or fully Net Zero-Energy renovation was 70 k€ per dwelling. This financial constraint is largely representative of the wider market conditions. Even forward-looking social housing operators find it impossible to justify such a large investment without exceeding regulated administrative caps on their cross-portfolio financial performance (which in the case of the Netherlands means keeping a 5% positive cash-flow across their operations).

Work Package 4 of the 2ndSKIN SCALER project has aimed at addressing the above-mentioned issues and propose an updated business plan for 2ndSKIN. It has done so by proposing a few tracks to achieve wider value-chain integration and improved financial feasibility. The following section lays out these paths. As research work is still ongoing through stakeholder workshop and interviews many of these findings of this process will be presented in the final project report in March 2019.

Current BIK Bouw Business model Scaler

BIK Bouw BV's "2ndSKIN" solution aims to facilitate the renovation of post-second world war porch apartment buildings by standardizing an external, non-intrusive combination of streamlined products and processes. This building typology amounts to over 520.000 houses in the Netherlands alone, with comparable numbers in Belgium, the UK, Germany, France, and northern Spain. BIK Bouw's value proposition is based on five key pillars:

1. An external, non-intrusive approach to sustainable homes.

2. Resident-centered approach based on minimum disturbance and clear communication.
3. A lightweight and high-quality shell for minimum maintenance.
4. Sustainable external installations (if possible Full Net Zero Energy).
5. Close collaboration with key supply-chain partners.

Having executed a successful 12-unit Net Zero Energy DEMONSTRATOR and a 183-unit ZE READY SCALER project, the future strategy of the company is to expand these key value propositions to some of the aforementioned markets in North-western Europe. The company currently offers two renovation levels (2ndSKIN Zero Energy READY and FULL Zero Energy), each with increasing levels of functionality and performance, on-site energy generation, and user-satisfaction monitoring. Average investment cost per dwelling per level of intervention range between 37.000 and 69.000 euros (before potential discounts if a volume of 300-units per year is reached).

Roadmap to value-chain integration and improved financial performance

Ongoing research during the SCALER project phase has aimed to reduce investment cost per unit and therefore increase financial attractiveness of the offering by following a number of strategic tracks. Based on these tracks a new business model will be proposed by the end of the project stage in March 2019.

The tracks can be divided into two groups:

Value-chain tracks are based on the creation or reinforcement of strategic alliances with key partners and suppliers:

1. BIK Bouw as single point of contact. During the DEMONSTRATOR phase two parallel value chains were proposed, one lead by BIK Bouw for the execution and management of the building envelope, and another one lead by Klimaatgarant for the execution and management of building services. This track proposes BIK Bouw acting as a single point of contact with the client, and subcontracting Klimaatgarant to fulfil their scope (while taking over some of their risks and costs).
2. Guarantee-based vs Service contract. The 2ndSKIN model is still based on the traditional product-centred approach of the construction industry, in which the final assembler (in this case the general contractor) retains guarantees over the delivered products and services. This approach raises costs and uncertainty, as future failures have to be accounted for at the start of the project, and translated into safety margins. An alternative model would split the cost of renovation into an installation component and an ongoing maintenance and monitoring service contract. Initial investment could be lower, as upfront safety and profit margins could be reduced, while the outsourcing of maintenance and management to the general contractor over the project's service life would represent an additional source of revenue while providing further incentives and responsibilities for ongoing performance. The strategic relationship between the service providing general contractor and its supply-chain would have to be strengthened even further in such a scenario.
3. Taking over suppliers' risks. The safety margins mentioned before, which are traditionally applied at every level of the supply-chain, could be reduced or eliminated by establishing ongoing partnerships or taking over guarantees and risks from sub-suppliers. Such a strategy could only be applied in the case of tested products from trusted partners, otherwise the risk taken by the general contractor would become too large.

Financial innovation tracks aim to increase the attractiveness of the investment by looking for collateral financing partners or lower-cost mechanisms to share the project cost:

1. Investment partnerships. While social housing corporations have access to subsidized financial resources, tightening control on their operations since 2008 have resulted in stricter accountancy practices requiring a minimum 5% cash-flow throughout their operations. This creates a chance for third-party investors to become involved as partners in the financing of projects, when traditionally they would have been unfeasible due to their higher capitalisation costs. Banks or investments funds, especially those focusing on ethical banking and sustainable investments, could be potential financing partners. Another option is the involvement of Energy Service Companies (or ESCO's) in the financing of energy saving systems, in exchange for taking over energy-related revenue from the project and/or a periodic service fee.
2. Lower interest rate due to higher property value or access to low-cost "Green funds". A measure better suited for the liberal market rather than the social housing one (due to the low capital cost of the latter). This would mean taking advantage of the sustainable characteristics of a Zero Energy renovation and the increase in property value after the project, to lower mortgage or loan interest rates related to the property. This could also be achieved by accessing targeted funds such as "Green funds" which have very low interest rates but high-performance conditions.

Upscaling strategy 2ndSKIN (2019)

The 2019 upscaling strategy can be summarised as follows:

- Strengthen the supply chain
  - Engage manufacturers, setup long term, scalable cooperation
  - Find additional partners
  - Bring cost price down to 60k€ for FULL Zero Energy and 35k€ for Zero Energy READY
- Unlock market for Zero Energy Renovation
  - Introduce 2ndSKIN concepts to Dutch prospects
  - Introduce 2ndSKIN concepts to European prospects.

The tracks described above are object of ongoing development through partner workshops and interviews, the results of 2ndSKIN Business Development will be presented in the final 2ndSKIN SCALER Project report in March 2019.

5. Knowledge Sharing & Transfer (WP5)

As the 2ndSKIN partners are from the supply side, it is very important to have an intensive dialogue with the stakeholders from the demand side and the policy makers who set the rules for (the transition in) the built environment.

During 2017 this dialogue was mainly executed -together with EIT Climate-KIC and TNO- by the use of Round Table Meetings. With the realisation of the 2ndSKIN DEMONSTRATOR project an important instrument was added to the portfolio of communication tools. One of the twelve apartments of the DEMONSTRATOR complex at the Soendalaan in Vlaardingen served as an information centre for interested stakeholders during the period from mid January until July 2018.

Residents of the 2ndSKIN DEMONSTRATOR project at the official opening of the information centre on 16th of January 2018

Communication tools that were used in 2018 within the SCALER project were:

- Social media
- Interviews
- Articles in general, professional and academic media
- Videos
- Round Table Meetings
- Presentations

Although there was a lot of interest of foreign press, the focus of the 2ndSKIN SCALER activities was on the Dutch Market in 2018, as being explained in the introduction of this report.

Social Media

2ndSKIN is actively communicating thru the following channels:

https://www.facebook.com/2nd-skin-219447175257301/

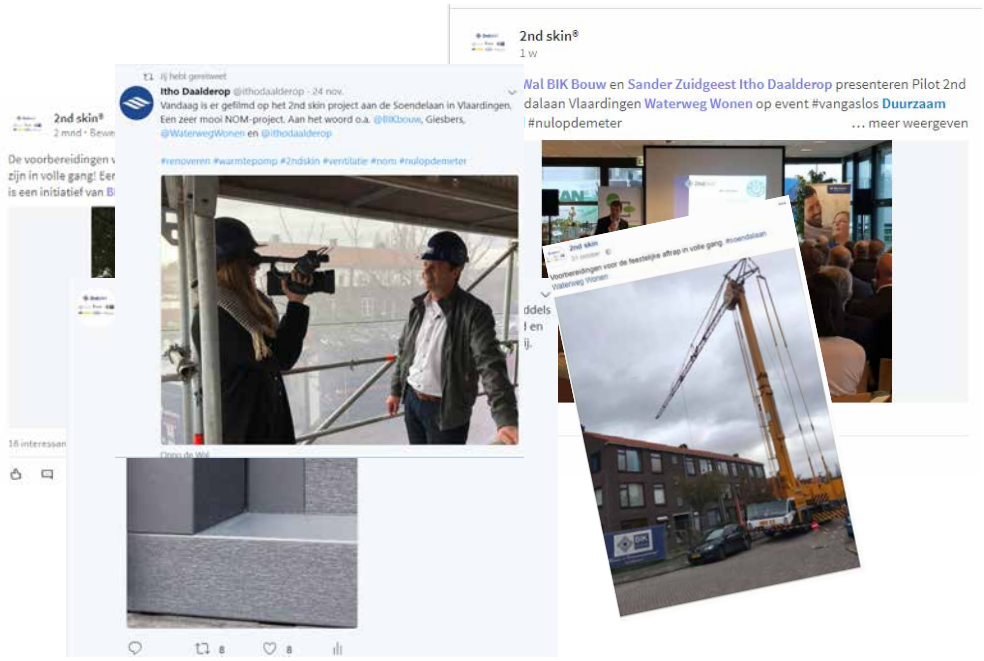
https://twitter.com/skin_2nd

https://www.linkedin.com/company/11315598/admin/updates/
https://www.instagram.com/2ndskn/

During the period April 2017 - December 2018 the scores on the social media were:

LinkedIn

- 145 followers



- 310 updates / news items
- updates shared by BIK and partners
- no paid ads used.

Twitter

- Views on average 1400
- Interaction on average 30
- updates shared by BIK and partners

Facebook

- Followers 31
- Reach: min 20, max 1800
- updates shared by BIK and partners
- no paid ads were used

Instagram, just recently added as communication tool.

Newspaper & professional articles

The `total number of public articles about 2ndSKIN at the beginning of December 2017 was 16 and 2 videos were made:

http://vakbladwarmtepompen.nl/itho-daalderop-wint-warmtepomp-award-2017/

http://vakbladwarmtepompen.nl/uniek-renovatieproject-maakt-12-portiekwoningennul-op-de-meter/Conclusions & next steps

https://www.installatietotaal.nl/news/item/uniek-renovatieproject-tovert-12-portiekwoningen-in-de-indische-buurt-om-tot-nul-op-de-meter-woninge/

http://www.bouwtotaal.nl/2017/12/eerste-2nd-skin-renovatie-vlaardingen/

https://www.construction21.org/articles/h/2nd-skin-a-solution-to-simplify-and-scale-up-renovations.htmlReferences

https://issuu.com/woningcorporatie_waterwegwonen/docs/watermerk_4_2017_online

http://bta.climate-kic.org/news/unique-deep-retrofit-project-in-vlaardingen/

http://www.sto.nl/nl/service/nieuws_80640.html

https://www.tudelft.nl/2017/bk/vlaardingen-homes-refurbished-to-become-zero-energy-buildings/

https://vlaardingen24.nl/nl/nieuws/nieuws/uniek-renovatieproject-soendalaan/19033

http://www.installatienet.nl/prijs-woningen-geisoleerde-tweede-huid-en-multiboiler-warmtepompsysteem/

https://www.gawalo.nl/klimaattechniek/nieuws/2017/12/warmtepompproject-van-het-jaar-2nd-skin-vlaardingen-1015415

https://www.delta.tudelft.nl/article/comfortabel-wonen-een-portiekflat

http://www.bikbouw.nl/index.php/blog/89-artikel-bouwbelang

https://devlaardinger.nl/Stad/Artikel/bik-bouw-renoveert-indische-buurt

Academic articles & papers

The results from the 2ndSKIN project were communicated thru the following academic articles (N=3) & paper (N=1):

Suárez, R., Escandon, R., López-Pérez, R., León-Rodríguez, Á. L., Klein, T., & Silvester, S. (2018). Impact of climate change: Environmental assessment of passive solutions in a single-family home in Southern Spain. *Sustainability (Switzerland)*, *10*(8), [2914]. https://doi.org/10.3390/su10082914

Guerra-Santin, O., Bosch, H., Budde, P., Konstantinou, T., Boess, S., Klein, T., & Silvester, S. (2018). Considering user profiles and occupants' behaviour on a zero energy renovation strategy for multi-family housing in the Netherlands. *Energy Efficiency*. https://doi.org/10.1007/s12053-018-9626-8

Escandon, R., Silvester, S., & Konstantinou, T. (2018). Evaluating the environmental adaptability of a nearly zero energy retrofitting strategy designed for Dutch housing stock to a Mediterranean climate. *Energy and Buildings*, *169*, 366-378. https://doi.org/10.1016/j.enbuild.2018.03.079

Boess, S., Silvester, S., de Wal, E., & de Wal, O. (2018, August). Acting from a participatory attitude in a networked collaboration. In *Proceedings of the 15th Participatory Design Conference: Short Papers, Situated Actions, Workshops and Tutorial-Volume 2* (p. 16). ACM.

Master Graduation Projects

In 2018 two Master Graduation projects related to the 2ndSKIN project were successfully ended:

- Quirine Henry: Circular Facade Refurbishment. MSc Architecture. TU Delft.
- Simone van den Elzen: Living comfortably and energy neutrally in an energy neutral home. MSc Design for Interaction. TU Delft.

Three Master Graduation projects are on-going:

- Rosanne Berkhout: Integrating Installations into zero-energy renovations. MSc Architecture TU Delft.
- Mick Simmering: Upgrading prefabricated facade systems for renovation of Dutch post-war apartments. MSc Architecture TU Delft.
- Elise Wabeke: Supporting residents to develop new practices in zero- energy homes. MSc Design for Interaction TU Delft.

Movies/VR-presentation

https://www.youtube.com/watch?v=ZKa56KMydmk

http://bikbouw.s3-website.eu-central-1.amazonaws.com/

https://youtu.be/a4rueoj5Mxc

Round Tables / Workshops[1]

A number of events were initiated or 2ndSKIN was invited to share the developed knowledge & insights. The events delivered a lot of follow-up activities resulting in submitting concrete proposals and negotiations for follow-up projects. The 12 April 2018 RENDA Round Table Event 2ndSKIN Vlaardingen is labelled and submitted as a EIT Climate-KIC CKIC04 KTI Key Performance Indicator.

The follow events took place in 2018:

1 Februari	#Van Gas Los Duurzaam Gebouwd
12 April	Renda Round Table Event 2ndSKIN Vlaardingen
17-19 April	Building Holland
22 June	Bouwend Nederland (Branche Organisation Dutch Buiding Industry)
12 September	Mediatour EIT Climate-KIC
20 September	Seminar Heathy Buildings
October	Heatpump Fair
23 October	Innovation Showcase Round Table, EIT Climate-KIC London
25 October	Workshop on 2ndSKIN during DRIVE, the annual Design Research & Innovation Festival during the Dutch Design Week Eindhoven https://www.clicknl.nl/drive/learning-to-live-in-an-energy-efficient-home/
OctoberNovember	2 Post Academic Lectures organised by TU Delft for Social Housing Stakeholders

Strategic Marketing & Communication Plan

The strategic marketing and communication plan is continuously updated and adapted to the enormous developments in Dutch politics on the Climate Change and more specific on the policy measures needed to reduce the CO2-emission in the built environment.

In Q1 2019 the 2ndSKIN SCALER Zero Energy READY product-/service solution will be discussed on its feasibility in Germany with the Social Housing Organisation Wohnstadt Krefeld.

[1] See Appendix uploaded file “4.2.7 2ndSKIN D2 Report on Upscaling Strategy” for Event Reports

6. Conclusions

All goals formulated for the 2ndSKIN SCALER project for 2018 are met.

The future looks bright for 2ndSKIN!

Having executed a successful 12-unit Net Zero Energy DEMONSTRATOR and a 183-unit ZE READY SCALER project, the 2019 strategy of the company is to expand these key value propositions to markets in North-western Europe.

Two follow-up projects in the Netherlands are in the pipeline for 2019.

The involvement of the network of the EIT Climate-KIC will be continued. Among others BTA Building Market Briefs will be used to make strategic choices for entering specific markets.

The company currently offers two renovation levels (2ndSKIN Zero Energy READY and FULL Zero Energy), each with increasing levels of functionality and performance, on-site energy generation, and user-satisfaction monitoring. A third offer, using Air-Water instead of the Water-Water heatpump technology, is under development. Average investment cost per dwelling per level of intervention range between 37.000 and 69.000 euros.

The 2ndSKIN upscaling strategy for 2019 will be aimed at:

- Strengthen the supply chain
  - Engage manufacturers, setup long term, scalable cooperation to develop next generation 2ndSKIN product-/services aiming at smaller, simplified integrated heating and ventilation systems, circular facade systems and interfaces supporting residents in their -energy neutral- lifestyle
  - Find additional partners.
  - Bring cost price down to 60k€ for the FULL Zero Energy and 35k€ for the Zero Energy READY product-/service solution.
- Unlock market for Zero Energy Renovation
  - Introduce 2ndSKIN concepts to Dutch prospects
  - Introduce 2ndSKIN concepts to European prospects. Cost reduction continues to be a key driver for the R&D of the 2ndSKIN consortium.

An agreement with EIT Climate-KIC is drafted for a return of their investment in 2ndSKIN.

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Silvester, S. e. (2017). 2ndSKIN Demonstrator. Performance Report 2017. Delft, 2ndSKIN consortium (Bik Bouw, TU Delft, TU Munchen & Province of Utrecht).

Tweede-Kamer (2018). Klimaatwet. The Hague, Tweede Kamer der Staten-Generaal.

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