D5.4 – Reports of field implementation at demo cases

WP5

Lead Partner: EMG

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Topic	EEB-07-2017 Integration of energy harvesting at building and district level
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Executive Summary

For the Northern Demonstration in the Envision project different plans and situation were worked out. The most a realistic plan is a renovation plan with housing corporations in Eindhoven and Helmond. Here 6 row dwellings will be renovated with the Envision heat harvesting technology. There will be a renovation design specific for the selected houses.

For the Southern Demonstration in the Envision project related to façade solar panels will be focused on the testing of ENVISON technology at District Level, in order to guarantee a high TRL. To do that, a proper design of the system is needed, and therefore, thanks to different small test cases of solar panels, it is possible to understand the best configuration of the system. The results in Savona showed that an installation of insulated panels, connected in series of 3 panels (from lighter to darker colour) could represent the best solution in order to optimize the panel performances. The available surface for the panel installation in Savona is around 90 m^2, therefore the chance of installing several panels can be considered. The panels are expected to be installed in the first semester of 2021, therefore the last definition steps in order to have a proper system design are occurring.

In the demo for the Envision PV glass in Austria the technology was demonstrated successfully on a bigger scale. Different lesson were learnt during preparation and installation.

The different Envision technologies can be combined very well. Harvesting both heat en electricity from the façades and windows is an excellent combination especially when the available roof surface is limited. This is in particular the case for high-rise buildings. The closed façade surface can be used for heat harvesting panels, the windows for PV windows or ventilated windows.

Table of Contents

List of Figures

1 Introduction

As described in the Grant Agreement the following demonstrations are planned:

- The Envision energy harvesting renovation concept in the Netherlands.
- The coupling of the Envision energy harvesting solutions in Genoa, Italy. In this coupling the heat harvesting panels are demonstrated and the ventilated window.
- The PV glazing solution in a Pilkinton building. The location changed from the Netherland to the office building in Austria.

In this deliverable the design, engineering, preparation and implementation status of the demonstrations is described of November 2020.

2 Northern Demonstration

This section describes the systems foreseen in the different plans for the Northern Demonstration

2.1 Plan A - Vestia - demonstration case

As mentioned in the project proposal Vestia contributes to the project by making an apartment building available which is on their renovation list. The proposal from Vestia is an apartment block in the Vosmaerstraat in Delft.

Apartment block Vosmaerstraat Delft

The proposed apartment block, a portico flat with a total of 24 apartments, dates from 1959 and shows features of the serial construction from the period after WOII. The apartments are based on a semi-sunken basement in which the storage rooms are included. The facade composition consists of concrete frames in which the façades are mounted. All horizontal concrete edges and balconies are one whole with the element floors. At the location of the partition walls concrete portals are provided, which form vertical lines.

The ground floor apartments have a garden on the north side. The apartments on the 2nd and 3rd floor have a balcony the south side. The composition of the facade is varied of fronts and balconies, held together by the concrete frames.

2.1.1 Description of the renovation concept (Plan A, version 1)

After an investigation by BAM and in consultation with Vestia the renovation approach is to build a separate framework around the building supported on a concrete foundation. In this framework façade elements are mounted which contain the insulation and the Envision heat collection technology. Typical for this renovation concept is the framework which carries the weight of the insulation and heat harvesting elements and not the existing concrete structure of the building. This framework will be founded on its own new foundation. The steps in this approach are visualised in the figure below.

- *Current existing situation*

- *Adding separate framework*

- *Removing the old facades*

- *Mounting the new facades*

Renovation steps to take in the renovation approach of BAM

At the end façades the elements which contain the insulation material and the Envision heat collection technology are mounted to the actual brick wall. The end facades have a significant contribution to the heat collection, because of the available collector area. Some essential structural principles of the approach are included in Appendix “Construction principles Plan A version 1”.

2.1.2 Budgeting of demonstration case (Plan A, version 1)

A building harvesting and renovation concept was developed and the applicable costs were budgeted by BAM. Below a summary of the last version of the budget of this case is presented. For the complete corresponding budget is referred to the appendix.

Description	Budgetted costs (incl. VAT)
Standard renovation measures	**€ 2,667,446**
Insulation existing facades and roof, window frames etc. Construction site costs etc.	
Integrated Envision renovation solution	**€ 900,139**

- Heat harvesting façade solution: - *Prefabricated façade elements including* - *mounting system with Envision heat harvesting panels* - *piping Envision panels* - *Installations to use the harvested heat in building* - Electricity harvesting roof solution: - *mounting system with PV panels and inverters*	
Total budget	**€ 3,567,585**

2.1.3 Conclusions (Plan A, version 1)

For the board of Vestia the conclusion of this budget was that the costs were unacceptable high. The board of Vestia concluded at the end of 2019 that is sees “no opportunities to create solutions in the short term, to realize a project”. The Vestia Board of Management indicated that the plan for the Vosmaerstraat with the incorporation of the Envision techniques is not appropriate due to the high costs for Vestia. This implies that the plan will not be approved by the board of Vestia.

According to the BAM the estimated costs were realistic. Because of these different opinions, on behalf of the consortium, TNO asked an external cost expert to investigate the case. The conclusions of this investigation were:

- The costs calculated by the BAM are competitive for this particular renovation approach.
- If another renovation approach can be found, the costs maybe reduced.

Despite different intensive mediation attempts from the coordinators, on behalf of the consortium, BAM and Vestia could not find a solution acceptable for both parties. It was decided that all partners (including Vestia) prefer the scenario in which the Consortium will develop an alternative renovation approach with an alternative contractor.

2.1.4 Description of the renovation concept (Plan A, version 2)

After the conclusion that Vestia and BAM could not reach a solution that was acceptable for both parties Vestia proposed another general contractor to make a proposal. This contractor with the name Van Mierlo-Dinkq made a renovation proposal where the external framework was omitted and timber frame element are mounted to the current concrete walls and floors of the building. After an inspection and investigation Van Mierlo-Dinkq concluded that mounting of the elements to these walls and floors was possible. The result of this approach is displayed in the figure below. Some essential structural principles of the approach are included in Appendix “Construction principles Plan A version 2”.

Design of the renovation for the version 2 approach by Van Mierlo-Dinkq

2.1.5 Budgeting of demonstration case (Plan A, version 2)

The version 2 renovation approach was worked out in a plan and the applicable costs were budgeted by Van Mierlo-Dinkq. Below a summary of the last version of the budget of this case. For the complete corresponding budget is referred to the appendix.

Description	Budgetted costs (incl. VAT)
Standard renovation measures	**€ 2,737,119**
Insulation existing facades and roof, window frames etc. Bathrooms, kitchens, toilets. Construction site costs etc. PV installation on roof*	
Integrated Envision renovation solution	**€ 1,250,910**

- Heat harvesting façade solution: - *Prefabricated façade elements including* - *mounting system with Envision heat harvesting panels* - *piping Envision panels* - *Installations to use the harvested heat in building*	
Total budget	**€ 3,988,029**

* In this case the PV installation is listed below the standard renovation measures. This is done, because there was some indication for possibility to get additional funding for the PV from another subsidy scheme.

At the end of 2019 it became clear that no accordance on the budgeting for this renovation could be obtained. The Vestia Board of Management informed the consortium that the plan for the Vosmaerstraat with the incorporation of the Envision techniques is not appropriate due to the high costs for Vestia. This implied that the plan was not approved by the board of Vestia. Possible scenarios for continuation were discussed amongst the partners;

- *Scenario 1: Vestia will provide a demonstration project and*
- *Scenario 2: Vestia will not provide a demonstration project (which would mean that Vestia is in breach which should be confirmed by all partners).*

On February 21st, 2020, Vestia has requested TNO to forward a Proposal for follow up and Annexes (explaining budget cuts and optimizations and planning) to all consortium partners. The proposal explained the maximum budget stretch Vestia has for the ENVSION project. In the EO GA meeting of March 2nd, 2020 it was concluded that the proposal was unacceptable for all partners. Vestia was appointed “in breach” by all partners, a formal letter was sent by TNO on behalf of the consortium. In a letter received from Vestia on March 30th and shared with the consortium, Vestia states that it does not see an opportunity, other than the already proposed and rejected solution from February 2020, to come to an acceptable and alternative solution to continue with the project. In the General Assembly (M30) of April 7th, 2020 different scenarios were discussed. Two possible scenarios were further investigated. First, a scenario in which the ENVISION project continues without Northern EU demonstration. Second, a scenario in which the Consortium searches for an alternative project.

2.1.6 Conclusions (Plan A, version 2)

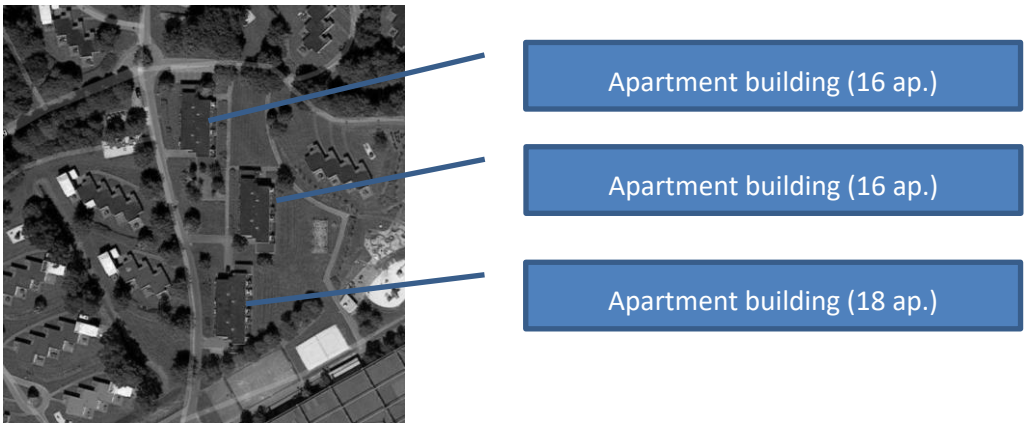
After a discussion with the Consortium it was decided in the meeting of April 7th that all partners (including Vestia) prefer the scenario in which the Consortium will develop a replacement project with another Party. Vestia was designated as “Defaulting Party” by the Consortium Partners. The lessons learnt in developing the Vestia renovation concept (besides the system and control strategy) will be reported, so that they can be used for future building projects.

2.2 Plan B – Pagedal - demonstration case

At the holiday park Pagedal in Stadskanaal, the Netherlands, there are three apartment buildings, with attached storage areas. The apartment buildings are located on the spaciously constructed holiday park,

which also consists of approx. 135 bungalows and a small campsite. Of the three apartment buildings, two consist of 16 holiday apartments, and one of 18 holiday apartments.

The apartment buildings consist of holiday apartments with a surface area of approx. 20 m^2. In total, the renovation proposal consists of 50 holiday apartments.



2.2.1 Description of the renovation concept

During spring 2020 a renovation solution was prepared by the consortium, containing standard renovation measures and the Envision renovation solution.

The standard renovation contains the following measures:

a. *Providing the crawl space with additional insulation; (approx. RC=1.3 -> approx. RC=3.5)*
b. *Providing the masonry walls with cavity wall insulation; (approx. RC=2.0 -> approx. RC=3.0)*
c. *Replacing wooden window frames for plastic window frames with HR++ glass;*

The Envision renovation solution contains the following measures:

a. *Envision panels (approx. 170 square meters of Envision-panels per apartment building consisting of 16 apartments), including installation solutions and architectural framework. The Envision solutions also functions as a sunblind for the upstairs apartments;*
b. *PV-integrated Roof Solution, including solar panel installation (approx. 50,000 Wp per apartment building consisting of 16 apartments) and additional roof insulation (approx. RC=2.5 -> RC=6.0);*
c. *PV-glass balcony fences (optional).*

The picture below shows a 3D-sketch of the actual situation.

Figure 1 - 3D-sketch: current situation

The picture below shows a 3D-sketch of the new situation. The black surface shows the Envision solution. Design and colorization of the Envision-panels has not yet been carried out. The picture only shows the 3D-sketch of the technical renovation proposal. The design and colorization of the Envision-solution will have lot of influence on the appearance of the apartment buildings.

Figure 2 - 3D sketch: new situation

In the picture below, another 3D-sketch of the new situation is displayed.

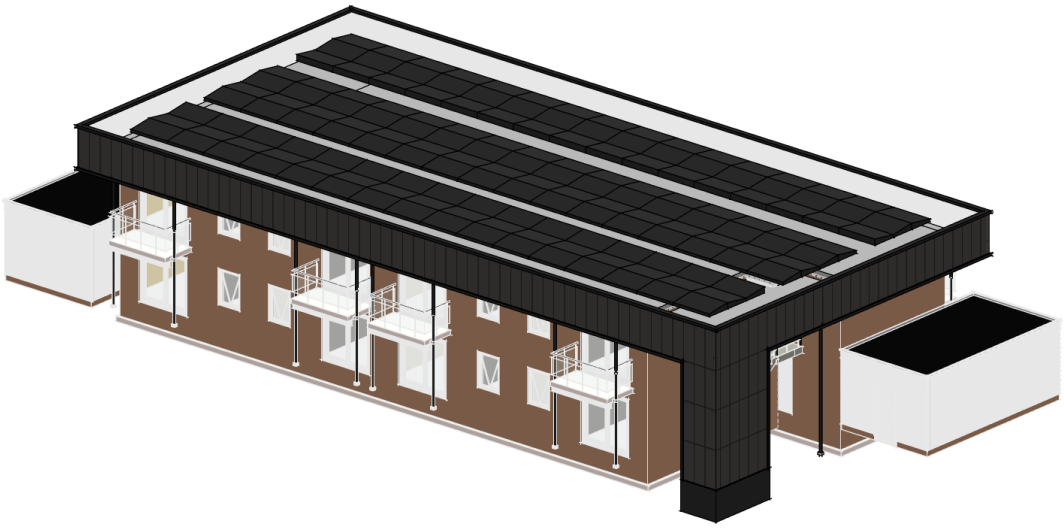


Figure 3 - 3D sketch: new situation

2.2.2 Budgeting of demonstration case

The costs of the renovation proposal are estimated as follows:

Subjects	Estimated costs
Standard renovation measures	**€ 240,000**
Insulation existing facades and floor, window frames etc.	

Integrated Envision renovation solution	€ 1,110,000
- Prefabricated elements including: - *mounting system with Envision heat harvesting panels,* - *roof insulation* - *mounting system with PV panels* - *piping Envision panels* - Installations to use the harvested heat in building	
Total estimate (total excl. VAT, for 3 apartment blocks)	**€ 1,350,000**

This estimate is exclusive of VAT, because for Pagedal this is the applicable situation.

2.2.3 Conclusions Plan B

The proposal of the demonstration seemed to be a good solution for the holiday parc Pagedal and together with the board of Pagedal a demonstration case of 32 appartments (2 buildings) was worked out. To our surprise, on Friday June 13th 2020 TNO received the message that the Pagedal board intended to revoke the decision, as the stakeholders (investors) of the parc could not agree with the plan for renovating only 32 apartments. Pagedal informed TNO that they are enthusiastic about the concept and willing to make their buildings available for the demo to succeed. Subsequently, Pagedal, Emergo and TNO have worked hard to look for solutions together. Meanwhile the effects of the Corona situation have become more clear for the parc; a major impact of this situation is expected in the future. The different solutions that were discussed did not seem to be possible. In the end, only under the conditions mentioned below the board and stakeholders of Pagedal could agree on making the buildings available for the ENVISION demonstration:

- *The aesthetic appearance of the three buildings (50 apartments) remains the same.*
- *A main contractor takes care of the entire project, including subcontractors. Pagedal does not bear any risk, not even financially in the context of pre-financing.*
- *The actual renovation work is limited to the low season (Q1 or Q4).*

Despite the positive approach from all parties involved and all the time that has been invested in making the demo at Pagedal a success, we are certain that the consortium cannot agree with the conditions of the board and the stakeholders of the parc to make their buildings available. If Pagedal joins the consortium, it will have to take the risks for the timely realization of the demo in the project, in accordance with the EU contracts and equal to all other partners. Furthermore, the financial risk related to pre-financing cannot be taken by the other partners. Under these conditions the consortium, unfortunately, cannot accept Pagedal to join the ENVISION project.

2.3 Plan C – Social housing row dwellings – demonstration case

In the area Eindhoven we found 2 social housing corporations that can make houses available for the demonstration of the Envision heat collection technology. The names of these social housing corporations are Trudo located in Eindhoven and Compaen located in Helmond.

Trudo's proposal is to renovate 3 different houses of the same type located in the neighbourhood Mensfort in Eindhoven:

- *1 row dwelling north-south oriented*
- *1 row dwelling south-north oriented*
- *1 row dwelling at the end of the row (more energy loss)*

Figure 4 – Mensfort neighbourhood in Eindhoven

Figure 5 – Type of row dwelling for renovation - Trudo

Copaen's proposal is to renovate 3 different types of houses in 2 different neighbourhoods with different renovation approaches. The row dwellings are located in de neighbourhoods Gansenwinkel and Het Hout in Helmond and are displayed in the figure below.


Vogezen 23


Baarsstraat 2


Dolomieten 48

Figure 6 – 3 different row dwellings for renovation owned by Compaen

2.3.1 Description of the renovation approach

The reasons to aim for a row dwelling instead of apartment blocks is that you can demonstrate a complete ENVISION renovation concept and realise it in a much shorter time frame. For an apartment block you need an approval from the tenants. For a single row dwelling which has become available because the tenant is leaving this approval step is not necessary anymore. Among the selected dwellings are also some inhabited ones. The first reaction of these tenants with regard to the renovation is very positive.

For the different houses an energy calculation will be made to determine the right renovation approach and which insulation measures are required to reduce the heat demand of the house in a way the Envision heat collection can harvest enough heat to keep the house warm the year round and provide for hot tap water.

2.3.2 Budgeting of demonstration case

The budget plan for this renovation will be written in the coming weeks and is not available at the moment.

2.3.3 Current status and planning

For the demonstration the following planning is foreseen:

Nov - Dec 2020 - Design of renovation

Jan - Mar 2021 - Renovation permits local government

Mar - Jun 2021 - Preparation for renovation and renovation

2.3.4 Conclusions Plan C

After a few attempts to come to a good renovation demonstration there is a realistic plan for the renovation with the housing corporations Trudo and Compaen. The plans will be worked out in an renovation design specifically for the selected houses. A significant advantage of the available row dwellings is the fact there is no approval required from the tenants.

3 Southern Demonstration (UGT)

The Southern Europe demosite is located in the Savona Campus, one of the venues of the University of Genoa, where a Smart Polygeneration Microgrid (SPM) is present. This Polygeneration Microgrid provides both electric and thermal energy to the Campus users. The ENVISION harvesting technologies (solar façade modules and ventilated windows) will be tested and evaluated in order to estimate their performances and their impact on the SPM.

3.1 Heat harvesting panels

3.1.1 Demonstration concept

The main goal of this demonstration is to test the performance of ENVISION system in interaction with a district network (both thermal and electrical). To do that, the implemented layout is the one shown in Figure 8. The solar panels are connected to the heat pump that works as a temperature booster in order to guarantee the 75°C required in the DHN; a small thermal storage is present to mitigate solar fluctuations on the HP. A CHP unit (a 100 kWe micro Gas Turbine) is present in order to provide both electric and thermal power. A thermal energy storage is installed in order to guarantee one more degree of freedom in the management of both thermal and electric demand.

Figure 7 Heat harvesting panel system rendering

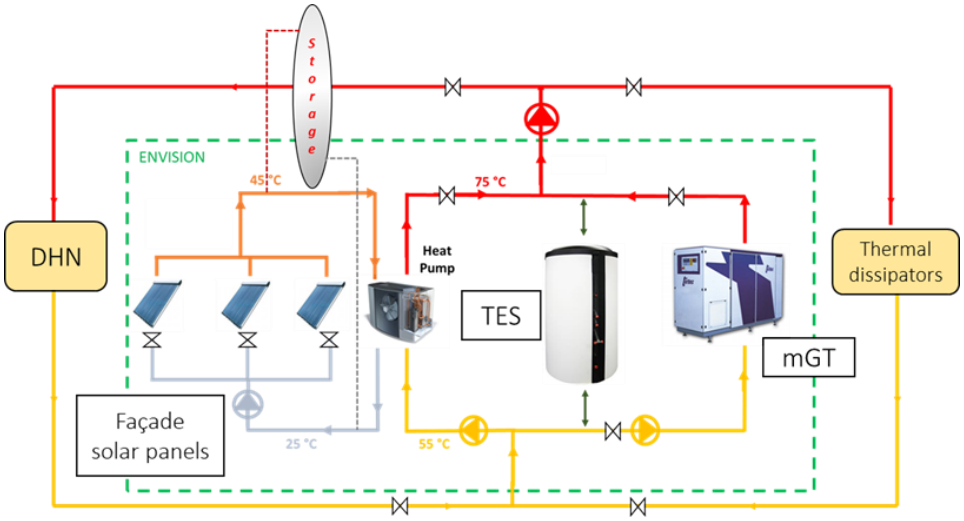


Figure 8 Heat Harvesting panels system

3.1.2 Current status and planning

In order to properly install the technologies included in the final Southern Demo, some renovation works are needed at Savona Campus. The pandemic of COVID-19 has caused some little delay in the bureaucratic procedure for the permit to start the work. In this sense, it is expected the beginning of the work in the last trimester of 2020, having the site ready for the first trimester of 2021.

In the meanwhile, some preliminary evaluations of panel performances have been done installing some panels in Savona Campus as shown in Figure 9.

Figure 9 Preliminary Demo at Savona

Two panels are connected in series and two in parallel in order to understand which configuration performs better. To do that, some sensors have been installed evaluating the temperatures and mass flow rate.

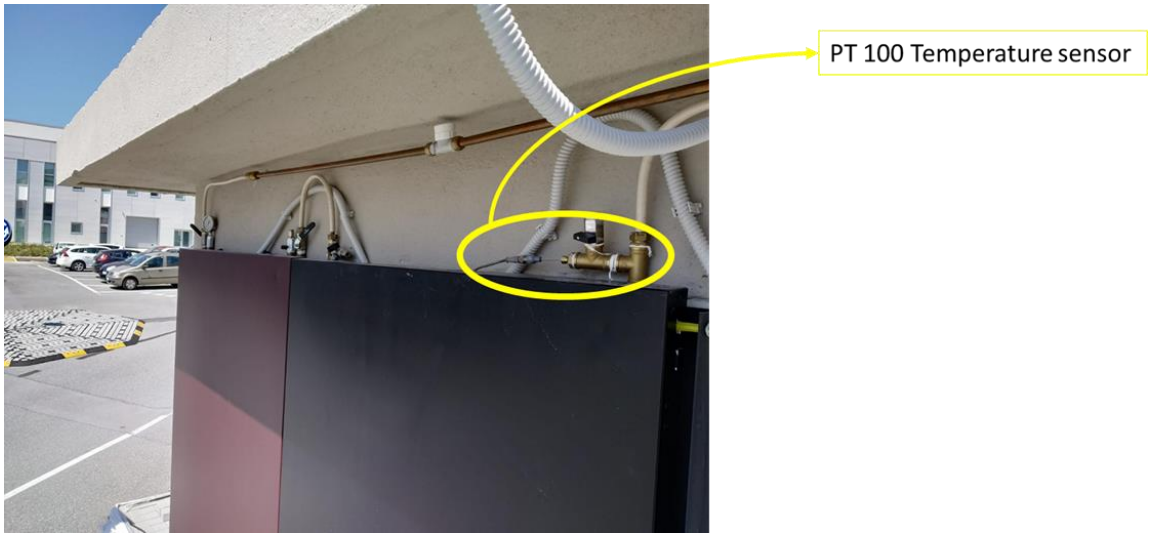


Figure 10 Temperature sensors detail

The heat capacity of the installed system was pretty small; therefore, it has been decided to dissipate the heat produced in ambient via a forced ventilation heat exchanger. Furthermore, the different performance between a panel with insulation on the back, and a standard panel has been evaluated.

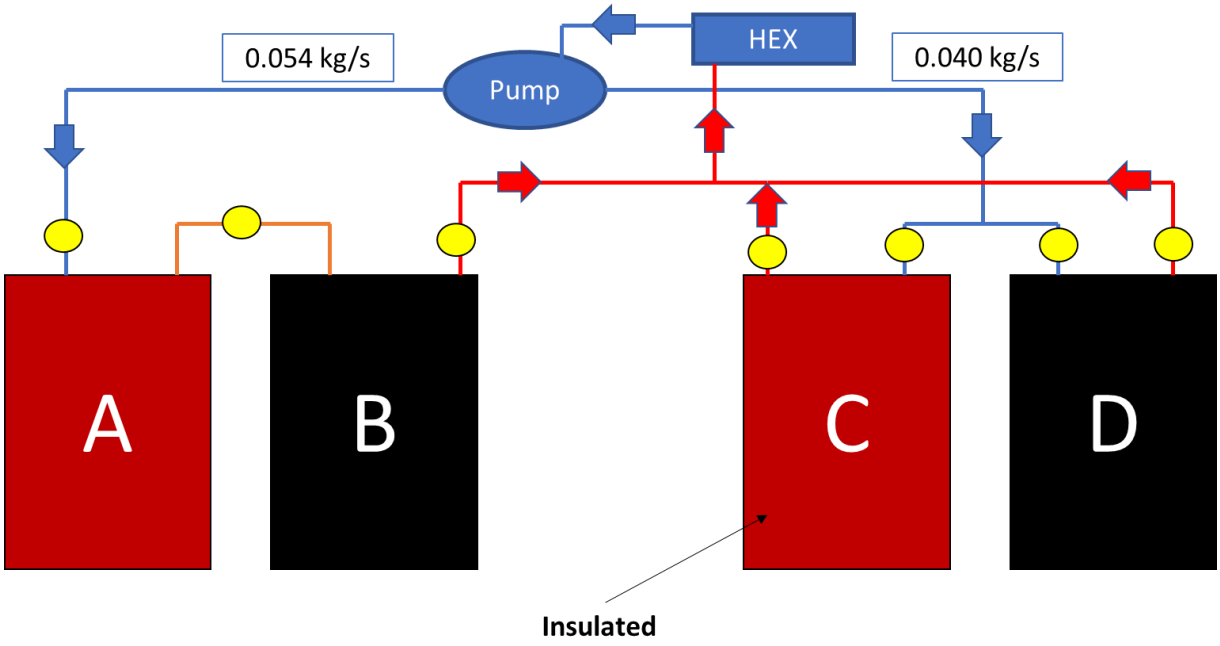


Figure 11 PreDemo layout

The main positive feedback from the installation activity, in terms of quality of the technology, has been related to its easy installation technique and the low weight of the panel. On the other side, it has to be considered a method to improve the aesthetic, implementing a coverage for the hydraulic system that is quite voluminous. The main interesting results are reported in Figure 12. It is worth noting that the presence of insulation on the back of the panel (panel C), guarantees a positive heat production even during particular cloudy periods.

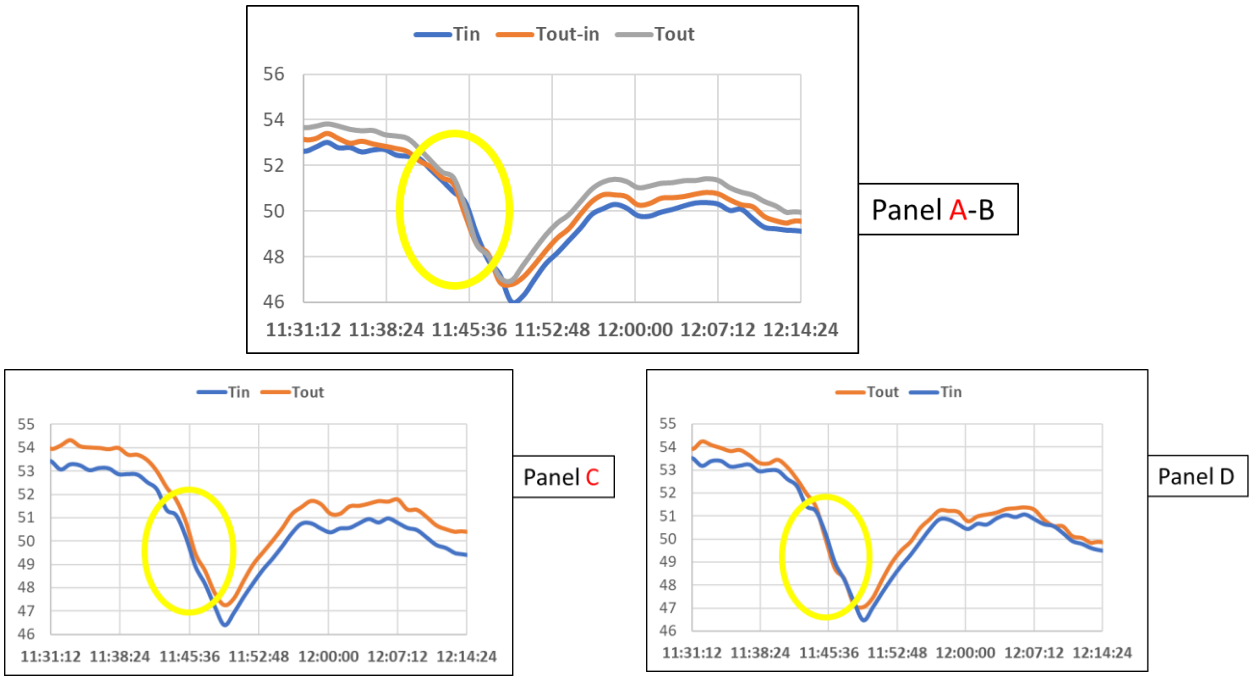


Figure 12 Temperature trends for the panels during Summer morning

The cited aspects in terms of temperature are confirmed by the results shown in Figure 13, where the heat produced by the panels is reported.

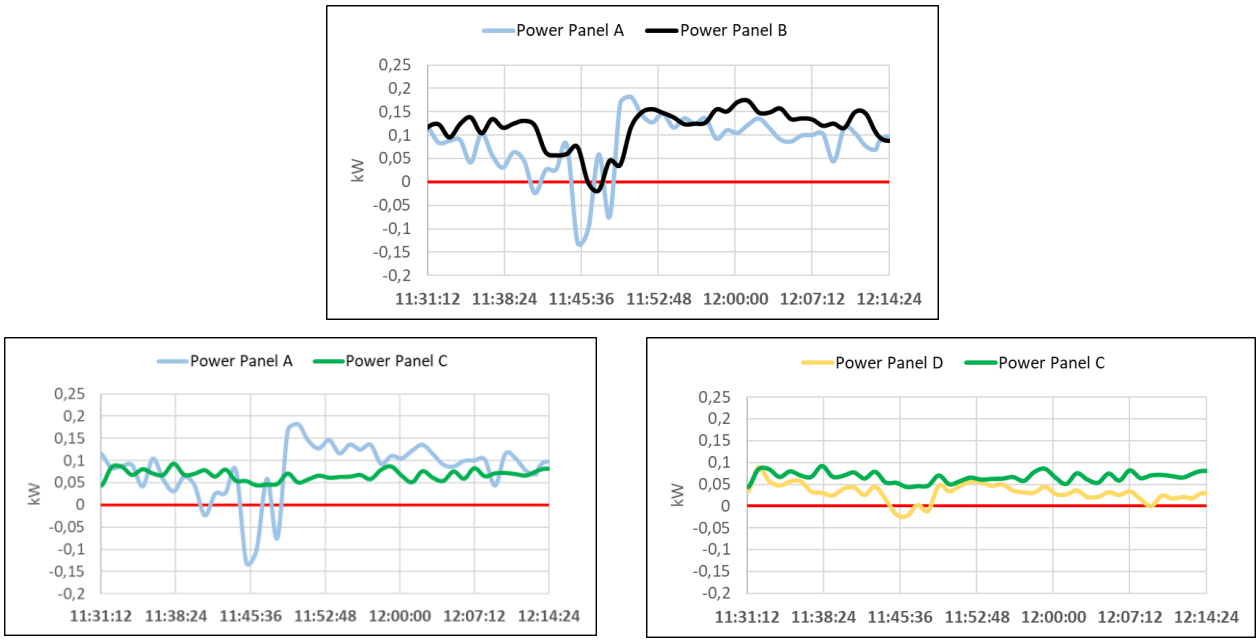


Figure 13 Heat produced by ENVISION panels

It is worth to underline that the insulated panel has a more constant behaviour, allowing to avoid thermal dissipations in ambient when the temperature in the panels is higher than the ambient one. Generally speaking, it can be considered that, for a South-East oriented façade, each panel (around 2 m^2 of surface) produce not more than 200 Wth. Furthermore, the panels in parallel seem to perform a little bit worse, but this aspect is also linked to the more shadowing that occurs on their side of the façade.

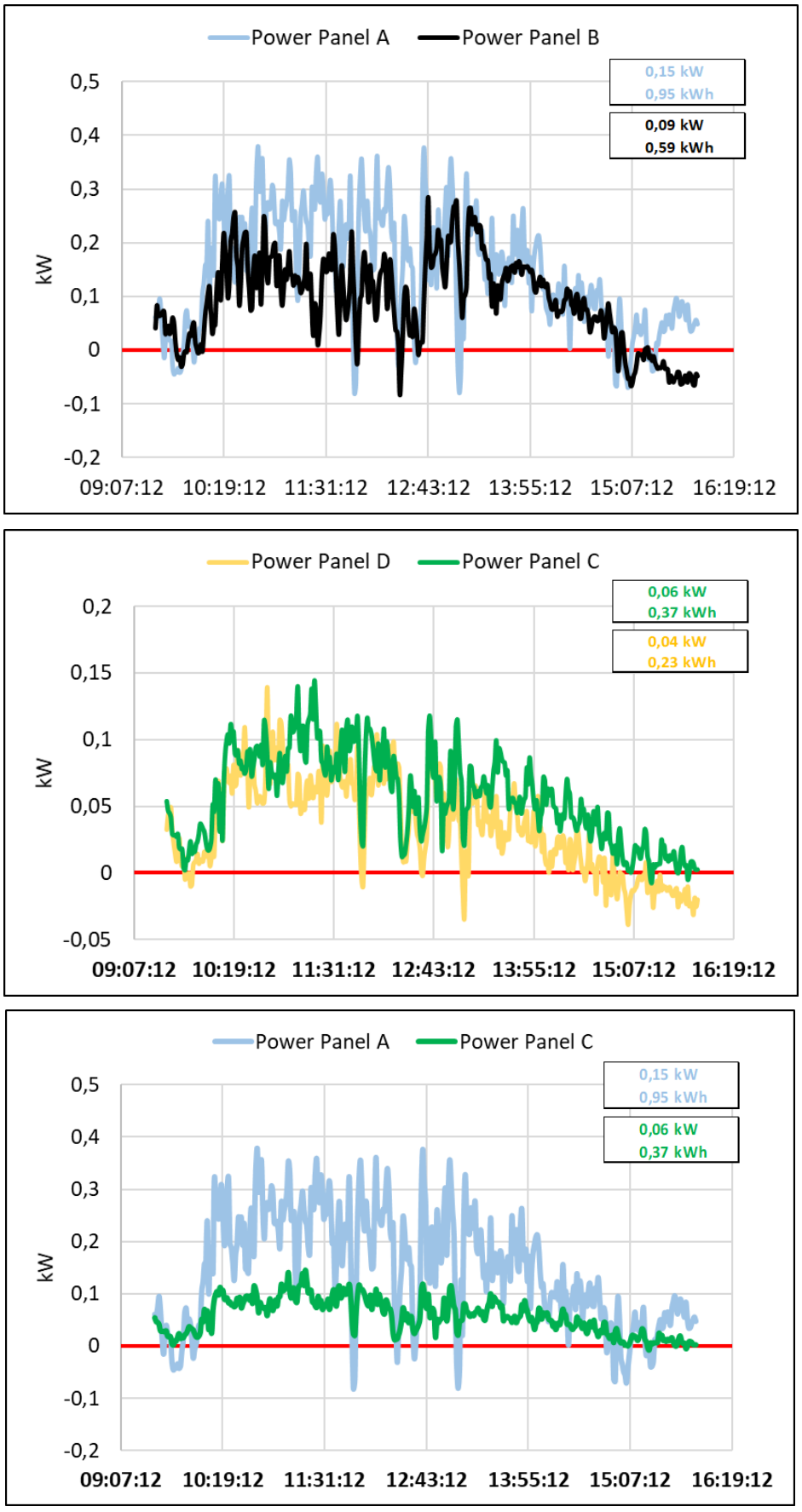


Figure 14 Daily monitoring of panels heat production in September

Moving to Figure 14, it is possible to investigate the daily behaviour of the panels. Due to shadowing, also from the first hours of the afternoon, the heat production decreases significantly. This aspect has even more impact on the panel performances. The insulated panel avoids thermal dissipations also in the late afternoon, confirming what has been stated previously. Considering the following equation for the calculation of the panel efficiency, the results are then reported in Table 1.

$$Efficiency = \frac{Power\ Panel}{Solar\ Radiation * Panel\ Area}$$

Table 1 Panels efficiency

Panel	Average Daily Efficiency	Peak Efficiency
A	10%	28%
B	5%	24%
C	4%	9%
D	2%	10%

The insulated panel presents more modest efficiency (even if the more shadowing on panels C and D has to be taken into account), therefore if compared with the closer one (Panel D) shows a better daily efficiency. The panels A and B have the advantage of a better exposition to solar radiation for most of the day. Considering the overall values of efficiencies, it is worth noting that they are calculated considering the values for a solar radiation on a horizontal surface, furthermore, in this configuration, the panels are pushed to work at quite high temperatures, where the solar panel efficiency curves are lower. This has been done considering the Southern Demo scenario, where a coupling of panels-HP with a District Heating Network represents the core of the test-rig.

3.1.3 Budgeting of demonstration case

The main budget regarding the heat harvesting panel system is reported below. The budgeting is related to both pre-demo and final demo site. The main costs are related to the cost of the panels and sensors. In this table the costs related to the acquisition system are not considered (around 10 k€). It is worth noting that the costs related to the installation are an estimation since that, this activity will be carried out by UGT suppliers.

Technology			UM	Unit Price [€]	Quantity	Total Amount [€]	Budget Item
A	NIR absorbing & colored coatings - Pre Demo	Panels + heat collectors+ piping	m2	256 €	8	2,048 €	13-EMG
		Hydraulic systems	lump sum	1,000 €	1	1,000 €	11-UGT
		Sensors	lump sum	3,000 €	1	3,000 €	11-UGT

		Logistic	lump sum	1,200 €	1	1,200 €	13-EMG
		Installation	lump sum	3,000 €	1	3,000 €	11-UGT
	Total A					**10,248 €**	
B	**NIR absorbing & colored coatings - Demo**	Panels + heat collectors+ piping	m2	230 €	62	14,260 €	13-EMG
		CHP Unit	kW	1800€	100	180,000 €	11-UGT
		Hydraulic systems	lump sum	7,000 €	1	7,000 €	11-UGT
		Sensors	lump sum	8,000 €	1	8,000 €	11-UGT
		Logistic	lump sum	1,700 €	1	1,700 €	13-EMG
		Installation	lump sum	6,000 €	1	6,000 €	11-UGT

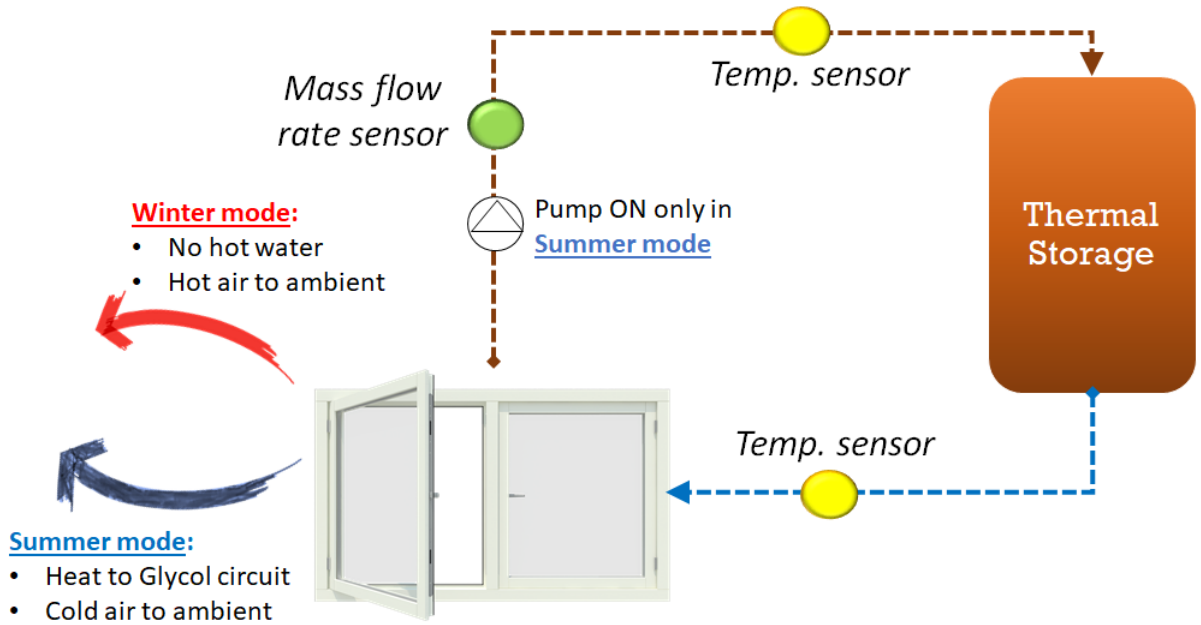
3.1.4 Conclusions

The section of Southern Demo related to façade solar panels will be focused on the testing of ENVISON technology at District Level, in order to guarantee a high TRL. To do that, a proper design of the system is needed, and therefore, thanks to different small test cases of solar panels, it is possible to understand the best configuration of the system. The results in Savona showed that an installation of insulated panels, connected in series of 3 panels (from lighter to darker colour) could represent the best solution in order to optimize the panel performances. The available surface for the panel installation in Savona is around 90 m2, therefore the chance of installing several panels can be considered. The panels are expected to be installed in the first semester of 2021, therefore the last definition steps in order to have a proper system design are occurring.

3.2 Ventilated window

3.2.1 Demonstration concept

The second technology tested in Southern Demo is the Ventilated window. The aim of this testing phase is to evaluate its behaviour and the TRL reached, installing this technology in a real scenario. This stage comes after dedicated tests on the window design and performances at BestLab, with the aim of finalizing an optimum design for the window system. Two configurations are possible using this window: a winter mode with the aim to provide heated air inside the room; and a summer one that aims to produce DHW refreshing the air through a dedicated heat exchanger. The system will be connected in summer mode when the air flow is forced to pass through the heat exchanger, while in the winter mode the heat exchanger is by-passed. The figure below, shows the layout of the ventilate window system, referring to the Southern Demo Installation.



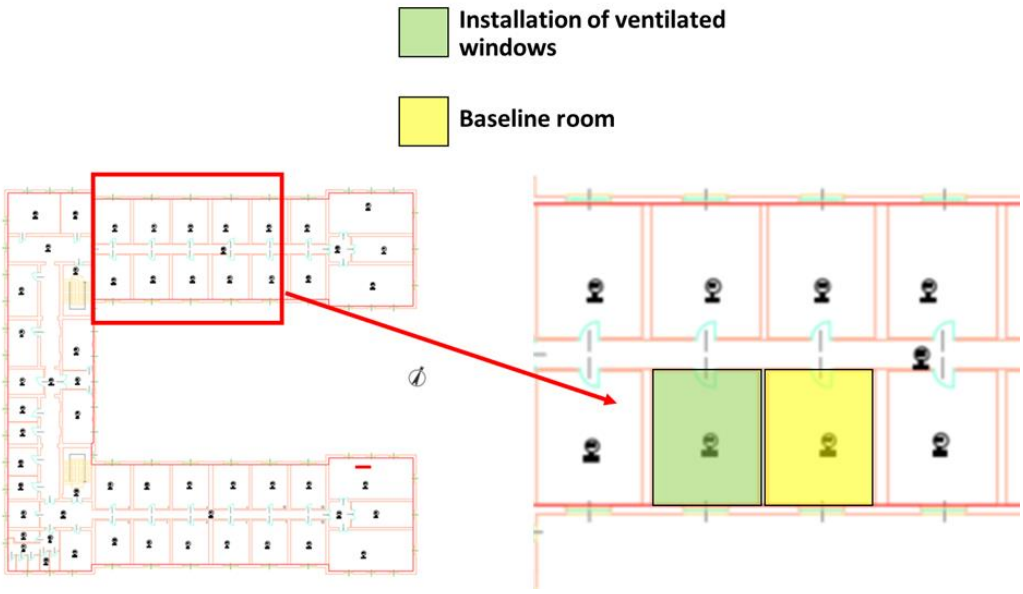
The ventilated window, in the Southern Demo, is not connected to any district system; therefore, a detailed control system is not needed. The only possible control could be on the water mass flow rate in order to evaluate possible impact on the outlet temperatures of the heat exchanger. The ventilated window, in the summer mode, will be free to heat up a Thermal Energy Storage, measuring the performance of the system by the energy stored inside the storage. During the winter mode, the window will blow hot air in the considered office; measurement of ambient conditions in a "twin-office" and in the "ventilated window office" will be collected in order to understand the performance of the installed system in comparison with the standard ambient provided by the centralized conditioning in the offices of Savona Campus.

3.2.2 Current status and planning

The window system will be installed between Dec 2020 to Jan 2021 in the selected office inside Delfino building at Savona Campus. The window is highlighted in the figure below. The office has been chosen accurately in order to guarantee good solar radiation (South oriented without shadowing).

All the offices inside the building have a centralized air conditioning system that can be then adjusted by any single office user. The centralized air conditioning system will be turned off during the experimental campaign inside the test room. The indoor conditions, of the "ventilated window office" and the "twin office" will be monitored by a system supplied by RINA that is able to evaluate the quality of the environment inside the room. The baseline room has same dimensions of the "test room", therefore similar behaviour it is expected in terms of heating and cooling needs. Furthermore, in order to analyse possible differences in the behaviour of those rooms, an initial monitoring of the two rooms is planned comparing them with the standard window installed.

The experimental campaign will take one year, beginning from the winter season. BGTech underlined that, in case of the provided system will not show encouraging results, small modifications in the system will be provided directly on the installed window in order to enhance its performances. This process will not require dismantling of the installed window.



3.2.3 Budgetting of demonstration case

For what concerns budget related to the ventilated windows demonstrator, the costs are mainly related to materials and logistic. The sensors cost is related to the experimental campaign therefore, at high TRL, these costs can be neglected.

	Technology	UM	Unit Price [€]	Quantity	Total Amount [€]	Budget Item	Notes
Ventilated window	Windows frame	m2	330,00 €	3,7	1.221 €	10-BGT	
	glass solution	m2	290,00 €	3,5	1.015 €	10-BGT	
	heat exchanger	lump sum	180,00 €	2	360 €	10-BGT	
	ventilation, filters	lump sum	169,00 €	2	338 €	10-BGT	
	glycol, pipes and switches	lump sum	158,00 €	1	158 €	10-BGT	
	digital thermometers	lump sum	45,00 €	3	135 €	10-BGT	
	valves and taps	lump sum	53,00 €	4	212 €	10-BGT	

	water tank	lump sum	300,00 €	1	300 €	10-BGT	
	air and water heat sensors	lump sum	45,00 €	4	180 €	10-BGT	
	Logistic	lump sum	1.000,00 €	1	1.000 €	10-BGT	
	grids with adjustable flaps	lump sum	63,00 €	8	504 €	10-BGT	
	glycol pumps	lump sum	190,00 €	2	380 €	10-BGT	
	Sensors	lump sum	8.000,00 €	1	8.000 €	11-UGT and RINA	Sensors both for installation room and "baseline room"
	Disassembly of existing window and installation of the new window	lump sum	600,00 €	1	600 €	10-BGT	windows BGTEC from the Heat exchanger UGT
	Installation (excluding disassembly of existing window and installation of the new window)	lump sum	500,00 €	1	500 €	11-UGT	windows BGTEC from the Heat exchanger UGT
Total C					14.903 €		

3.2.4 Conclusion on system concept, control strategy, and budget

The ventilated window is a system used for conditioning the air both in summer and winter period. During the winter period, solar energy is used to warm up air that is ventilated into the room. During summer hot air is cooled heating up tap water. The performance of this system will be evaluated by measuring the amount of energy produced by the window. To do that sensors to measure the air conditioning and water heating are installed.

To control the system a sensor situated in the upper part of the ventilated chamber switches the vents (in the set temperature), while pomp is activated by the sensor located near the radiator for detecting liquid temperature inside. It blocks the pump when the liquid is below an set temperature. A reference to D2.3 and D3.3 is made for further details.

BGTech is finalizing the ultimate design of the ventilated windows. Therefore, if pandemic restrictions will not affect the process, delivery and installation of the system will be performed by the Jan 2021. Then, the experimental campaign will begin in Savona Campus in the dedicated room. One full year of performance monitoring will be therefore performed within ENVISION project. Some on-line modifications could be developed by BGTech depending on the measured performances in order to enhance the system efficiency.

4 Austria Demonstration

4.1 Description of the renovation concept (plans)

The intervention consisted of the front façade renovation (replacement of frames and windows) of the NSG - Pilkington downstream production plant located in Austria. The building was interested by the following issues:

- *Problems of poor Isolation during winter*
- *Problems deriving from too much heat inside the building during summer*

The former windows, consisting of two glass panes combined to an insulating glass unit, were installed in 1992, with a rather poor thermal insulation (compared with todays standards) of U=1,5 W/m²K.

The façade orientation is abt. 160° south-east.

For the window parts the product Pilkington **Sunplus™** BIPV Vision (as a look-through solution) was chosen, which is only partly covered with solar cell stripes and ensures a good visible connection to the outside world. For the spandrel parts Pilkington **Sunplus™** BIPV Spandrel came into consideration, which is covered completely by the solar cell stripe technology. The area of the whole façade amounts to 66,5 m², consisting of 30,4m² vision parts and 36,1m² spandrel parts (see pictures below).

Figure 15 Façade to be renovated

Figure 16 Building location: Pilkington Austria GmbH Bundesstraße 24, 5500 Bischofshofen, Austria

Existing glass has been replaced using BIPV vision and BIPV spandrel.

4.2 Status of implementation and execution

4.2.1 Façade renovation

In August 2020 the new BIPV façade was installed – and finalized 11th September - at Pilkington Austria in cooperation with the building owner Techno-Z. The BIPV glasses - both spandrel and window parts - cover the whole vertical and southside oriented area (SE 160°).

The sizes and further aspects are summarized in the table and project questionnaire attached below, that was used NSG-Group internally.

The BIPV modules has been designed with respect to match aesthetic appearance and optimized solar gain of the façade. Thus the stripes in the upper windows have been lowered to prevent shadowing from the existing mullion-and-transom façade (efficiency), and all stripes have been aligned sidewise equal (aesthetic).

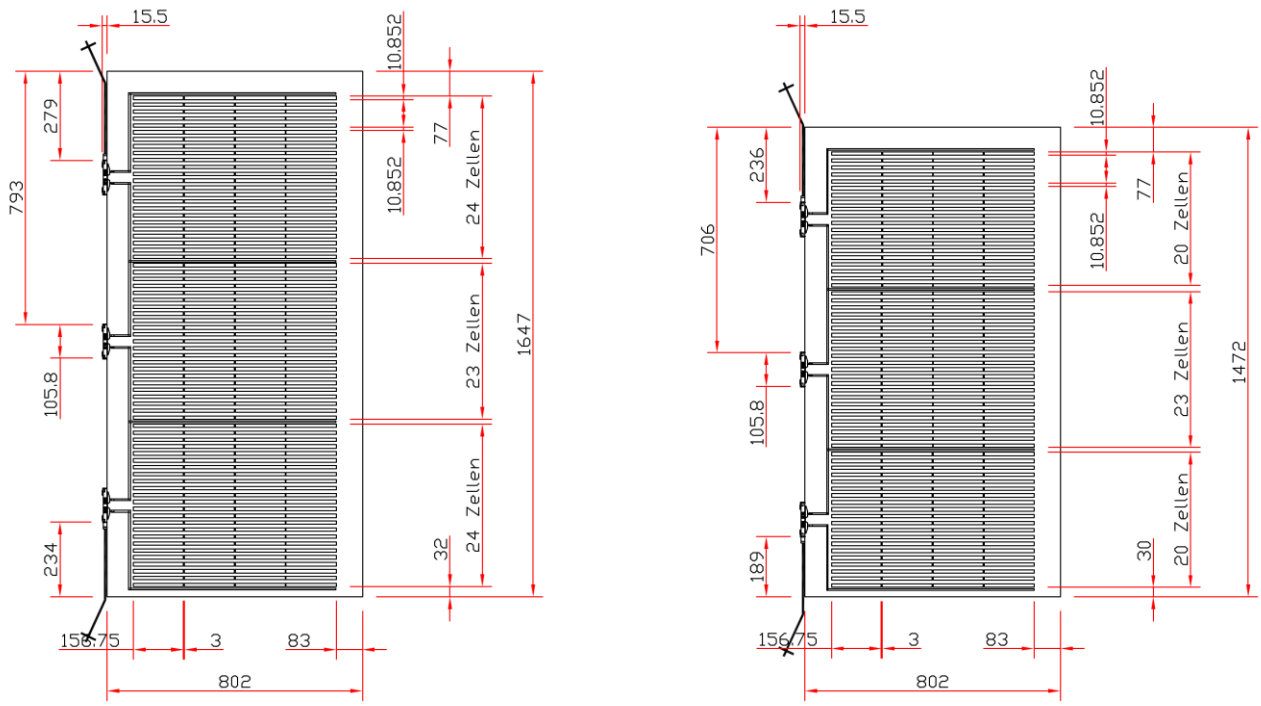


Figure 17 Design of the BIPV window modules with more free space (from cell to edge) on the top compared to the bottom to limit shadow on cells.

Several Project meetings were held involving the project team (NSG, TNO/SEAC Eindhoven, Wicona, Electrotechnik Kontriner), namely

- *21-11-2018 Bischofshofen*
- *03-09-2019 in Gelsenkirchen*
- *11-03-2020 & 2/4-09-2020 Bischofshofen.*

For the window parts the BIPV glass was integrated into an insulating glass unit (IGU), more specifically a TGU (triple insulating glass unit), with two further thermal insulating glass panes (4mm Pilkington **Optitherm™** S3), and including an additional solar control PVB-interlayer.

The overall thermal insulation of such an insulating glass unit is Ug= 0,65W/m²K (factor >2 better than before), and the total solar energy transmittance at only 18% (less than a fifth of the total solar energy). More data can be found in the datasheet below. The junction boxes for the vision part are mounted at the edge of the glazing.

The new Aluminium facade system stems from the company Wicona. As mullion-and-transom façade the system WITEC 60 (fixed parts) was chosen , and for the turn/tilt parts the system WICLINE 75 EVO. For all the metal works we accepted the offer from the company Harasser.

The electric installations were done by the company Kontriner Elektrotechnik, and much care was taken to achieve a thoroughly cabling. For maintenance reasons the interconnection between all BIPV glasses is placed in the inside of the room. The cabling itself is hidden in the frames.

An overview and some details are summarized here:

For the aluminium Frames, NSG relied on the following suppliers:

- Wicona GmbH - Pirching 90, A-8200 Gleisdorf
  - Model Wictec 60 (fixed frames part)
  - Model Wicline 75 EVO (turn/tilt part)

The installation was performed by a Solar Installation Company :

- Elektrotechnik Installationsfirma (Elektrotechnik Kontriner, Molkereistr. 10, 5500 Bischofshofen, Österreich; http://www.elektro-licht.at)

Care was also taken to make sure, that enough light does encounter the room. Here regulations do exist to ensure the well-being of employees. As stated earlier this holds also for the total solar transmittance by applying an extra IR absorbing PVB interlayer to prevent overheating of the office rooms.

Below, technical data oft he glass installed are reported, as well as picture of the intervention.

Pilkington-NSG
Pilkington **Sunplus™** BIPV
Preliminary Energy Estimate
Tool: http://pvwatts.nrel.gov/pvwatts.php
Date 11.03.2020

Project Data	
Project name	Pilkington Austria BIPV Facade
City	Salzburg (nearest location)
DS System Size (kW)	7,4
Module Type	Premium
Array Type	Fixed (open rack)
System loss (%)	14,08%
Tilt (Degrees)	90°
Azimuth (Degrees)	160°
DC to AC Size Ratio	1,2
Inverter Efficiency (%)	96
Ground Coverage Ratio	0,4

Window and Panel Parameters								
System	Orientation	W (mm)	L (mm)	N cells W	N cells L	Power(W)	Qty	Total Power(kW)
S1 Vision	160°	805	1647	4	71	95,6	6	0,57
		807	1466	4	62	84,0	3	0,25
		805	1472	4	63	85,9	6	0,52
		807	1291	4	54	74,1	3	0,22
		805	1472	4	63	85,9	6	0,52
		807	1291	4	54	74,1	3	0,22
							27	**2,30**
S2 Spandrel	160°	805	1237	4	27	130,4	6	0,8
		988	1237	5	27	163,0	3	0,5
		805	1444	4	33	159,3	6	1,0
		988	1444	5	33	199,2	3	0,6
		805	1448	4	33	159,3	6	1,0
		988	1448	5	33	199,2	3	0,6
		805	747	4	15	72,4	5	0,4
		988	747	5	15	90,5	3	0,3
							35	**5,0**
Total							**62**	**7,31**

KWh/Year of energy savings due to Solar Production (PV Watts)			
System	**Orientation**	**DC System (kW)**	**PV Watts (Kwh/year)**
S1	160	2,3	4691,00
S2	160	5,0	
Total :		**7,3**	**4691,00**

PROJECT QUESTIONNAIRE

Date: 16/03/2020

Contact Information:	
Name	Michael Lackner
Company Name	Pilkington Austria GmbH
Address	Werksgelände 24, 5500 Bischofshofen
Phone Number	+43 664 1603735
E-mail	Michael.Lackner@at.nsg.com

Project Participants:	
Building Owner	Techno_Z Pongau-Pinzgau-Lungau GmbH
Architect	DI. Robert Schranz
General Contractor	
Glazing Contractor	
Electrical Contractor	Elektrotechnik Kontriner

Project Information:	
Project Name	Pilkington Austria BIPV façade
Building Type	Sunplus BIPV Vision and Spandrel
Address and Location	Werksgelände 24, 5500 Bischofshofen
Geographical coordinates	47.399227, 13.217190
Start Design Date	
Glass Installation Date	
Building Size (Length, Width, Height) in m^2	
Total Interior Area (m^2)	BIPV Vision: 31,86 m^2 BIPV Spandrel: 37,40 m^2
Total Number of Glass Unit	BIPV Vision: 27 Pieces BIPV Spandrel: 35 Pieces

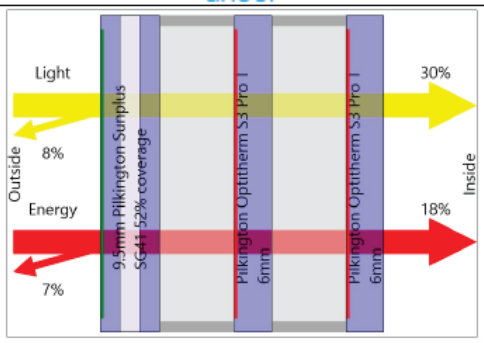
Solar Glass Unit Description (use additional pages if necessary):								
Serial Number	Type (Skylight/ Window/ Wall)	PV Type (PowerVision/ PowerSpandrel)	Glass Width (mm)	Glass Length (mm)	Quantity	Area (m^2)	Tilt Angle (degree) Horizontal = 0° Vertical = 90°	Orientation (degree) North = 0° East = 90° South = 180° West = 270°
1	Var.2	BIPV Vision	805	1647	6	7,93	90°	SE 160°
2	Var.2	BIPV Vision	807	1466	3	3,54	90°	SE 160°
3	Var.2	BIPV Vision	805	1472	6	7,08	90°	SE 160°
4	Var.2	BIPV Vision	807	1291	3	3,11	90°	SE 160°
5	Var.2	BIPV Vision	805	1472	6	7,08	90°	SE 160°
6	Var.2	BIPV Vision	807	1291	3	3,11	90°	SE 160°
7	Var.2	BIPV Spandrel	805	1237	6	5,97	90°	SE 160°
8	Var.2	BIPV Spandrel	988	1237	3	3,67	90°	SE 160°
9	Var.2	BIPV Spandrel	805	1444	6	6,97	90°	SE 160°
10	Var.2	BIPV Spandrel	988	1444	3	4,28	90°	SE 160°
11	Var.2	BIPV Spandrel	805	1448	6	6,99	90°	SE 160°
12	Var.2	BIPV Spandrel	988	1448	3	4,29	90°	SE 160°
13	Var.2	BIPV Spandrel	805	747	5	3,01	90°	SE 160°
14	Var.2	BIPV Spandrel	988	747	3	2,21	90°	SE 160°

NSG Pilkington
Hall Lane, Lathom
L40 5UF
Lancashire
www.pilkington.com

Technical Module Data

Module type	Floor	Type	Pcs.	Width (mm)	Heigth (mm)	Total area (sqm)	Pmpp (Wp)	Vmpp (V)	Impp (A)	Voc (V)	Isc (A)	Fill factor (FF)	Drawing number	Amount of string rows (parallel)	Amount strings per module (serial)	Sum power (Wp)
Pilkington **Sunplus™** BIPV Vision	1. OG	Fixverglasung	6	802	1647	7,93	95,61	39,18	2,44	46,87	2,63	77,62%		4,0	71	573,66
	1. OG	Dreh-/Kippflügel	3	804	1466	3,54	83,95	34,35	2,44	41,19	2,62	77,70%		4,0	62	251,85
	2. OG	Fixverglasung	6	802	1472	7,08	85,90	35,09	2,45	42,00	2,62	78,05%		4,0	63	515,40
	2. OG	Dreh-/Kippflügel	3	804	1291	3,11	74,08	30,18	2,45	36,13	2,63	78,10%		4,0	54	222,24
	3. OG	Fixverglasung	6	802	1472	7,08	85,90	35,09	2,45	42,00	2,62	78,05%		4,0	63	515,40
	3. OG	Dreh-/Kippflügel	3	804	1291	3,11	74,08	30,18	2,45	36,13	2,63	78,10%		4,0	54	222,24
	Sum					**31,86**										**2300,79**
Pilkington **Sunplus™** BIPV Spandrel	1. OG	Fixverglasung	6	805	1237	5,97	130,40	14,90	8,75	17,90	9,20		PM86077	4,0	27	782,40
	1. OG	Fixverglasung	3	988	1237	3,67	163,00	14,90	10,94	17,90	11,50		PM86078	5,0	27	489,00
	2. OG	Fixverglasung	6	805	1444	6,97	159,30	18,20	8,75	21,90	9,20		PM86079	4,0	33	955,80
	2. OG	Fixverglasung	3	988	1444	4,28	199,20	18,20	10,94	21,90	11,50		PM86080	5,0	33	597,60
	3. OG	Fixverglasung	6	805	1448	6,99	159,30	18,20	8,75	21,90	9,20		PM86081	4,0	33	955,80
	3. OG	Fixverglasung	3	988	1448	4,29	199,20	18,20	10,94	21,90	11,50		PM86082	5,0	33	597,60
	4. OG	Fixverglasung	5	805	747	3,01	72,40	8,27	8,75	10,00	9,20		PM86083	4,0	15	362,00
	4. OG	Fixverglasung	3	988	747	2,21	90,50	8,27	10,94	10,00	11,50		PM86084	5,0	15	271,50
	Sum					**37,40**										**5011,70**

*Spectral data Pilkington **Sunplus™** Vision, installed in Façade Bischofshofen:



Description

Position	Product	Process	Thickness (nominal) mm	Weight kg/m²
Glass 1	9.5mm Pilkington Sunplus SG41 52% coverage	Laminated	9.5	20.81
Cavity 1	Air: 10%, Argon: 90%,		12	
Glass 2	Pilkington Optitherm S3 Pro T 6mm	Coated + Toughened	6	15
Cavity 2	Air: 10%, Argon: 90%,		12	
Glass 3	Pilkington Optitherm S3 Pro T 6mm	Coated + Toughened	6	15
Product Code	9.5L-12Ar-Ot6T-12Ar-Ot6T		45.5	50.81

Performance

Light		
Transmittance	LT	30%
	UV	0%
Reflectance Out	LR out	8%
Reflectance In	LR in	13%
Energy		
Direct Transmittance	ET	14%
Reflectance	ER	7%
Absorptance	EA	79%
Total Transmittance	g	0.18
Shading Coefficient Total		0.21
Shading Coefficient Shortwave		0.16

Sound Reduction	Rw dB (C;Ctr)	Upon Request
Thermal Transmittance	W/m²K	0.7

Ra	90

Performance Code	
U-Value/Light/Energy	0.7 / 30 / 18

The values of some characteristics are displayed as NPD. This stands for No Performance Determined.

NSGSpectrum allows you to combine a wide range of products available from Pilkington and determine their key properties such as light transmittance, g value and U value. The program includes restrictions that prevent some combinations being selected that may be considered unwise or impractical. Even with these restrictions, it is still possible to create product combinations that may not be available from your supplier. Please check with your supplier that your chosen product combination is possible, available in the sizes required and in a timescale appropriate to your project. Furthermore, it is essential that you check that your product combination is appropriate for satisfying local, regional, national and other project-specific requirements.

Calculations are made according to EN410/EN673:2011

*Remarks:

- *Pilkington **Sunplus™** substrate based on extra-clear glass Pilkington Pilkington **Optiwhite™***
- *Important for HVAC savings: TL/g = 30%/18% due to additional NIR absorbing PVB interlayer behind PV cells. With a conventional PVB interlayer the TL/g would have been 35%/28%, i.e. reduction in total solar transmittance of ~10%.*

Figure 18: Photos taken during renovation 3rd and 4th of September 2020 - location Pilkington Bischofshofen

20200903-PiA-Austri a-TechnoZ-power-o

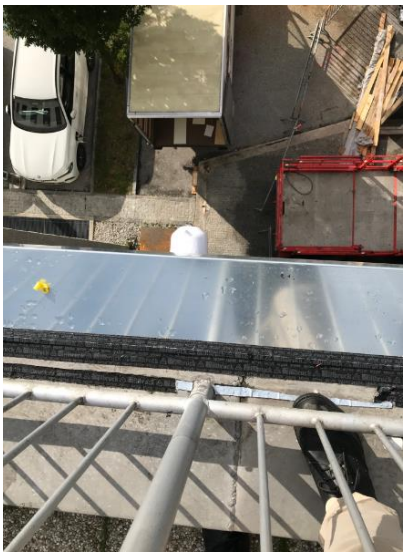
20200903-PIA-Austri a-BIPV-Questionaire

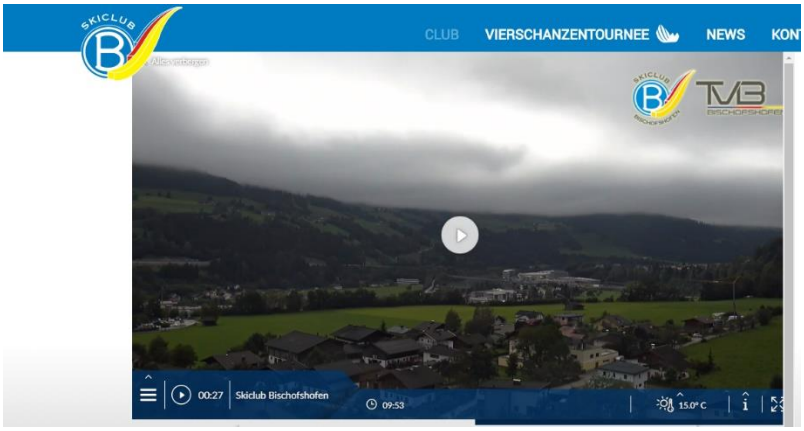
TGU_BIPV_Bischofs hofen_new.pdf

4.2.2 Weather measurements / detail invertor - Bischofshofen

Monitoring of the (boundary) conditions (outdoor weather data), coupled with the electricity produced by photovoltaic systems will allow the ENVISION's project team to clearly define the performances of the renovated façade. According to the monitoring plan defined in D5.2, the following sensors/measurement have been installed/identified

- *Laptop installed with WLAN connection*
- *Inverter Solaredge SE7K*
- *Pyranometer installed at Façade Bischofshofen with 24/7 connection with TNO*
- *Weather data:*
- *Supplied by Meteoblue Basel Switzerland - www.meteoblue.com*
- *Simulation data with high precision (https://content.meteoblue.com/en/content/view/full/3509)*
- *Professional weather station in Bischofshofen, Austria.*
- *https://goo.gl/maps/6xJhdSrgM8NTXr5w6*
- *History+ calculates the data for the whole grid cell, so it does not matter if the location is not exactly in the coordinates requested*
- *Full year contracts (Point+ and History+) for Pilkington Nederland BV*
- *Impression actual weather region Bischofshofen:*
- *https://www.skiclub-bischofshofen.at/de/club/service/webcam/*
- *Direct access to Monitoring / Dashboard Solaredge, sophisticated layout, measures each specific solar panel.*
- *www.solaredge.com*

	
Pyranometer at the Façade	Weather station Bischofshofen

	
Invertor in cellar (for the monitoring of electricity produced)	Webcam area Bischofshofen

4.3 Typical budget for this renovation

Technology	Item		UM	UNIT PRICE [€]	Quantity (area)	Total Amount [€]	Budget Item (see table 3.4 b GA)	Notes
PV Window	**D-1**	Pilkington Sunplus™ - BIPV Vision	m^2	1.979 €	32,29	63.896 €	7 - NSG1	Including Logistics
	D-2	Lamination of vision part	lump sum	27.842 €	-	27.842 €	8 - NSG2	Including Test - Certification costs part Lamination / Glass costs for Vision part (50% € 3647,-)
	D-4	Lamination of spandrel part	lump sum	32.229 €	-	32.229 €	8 - NSG2	Including Test - Certification costs part Lamination / Glass costs for Spandrel part (50% € 3647,-)
	D-5	Installation vision part	lump sum	3.929 €	-	3.929 €	7 - NSG1	Vision + spandrel
	D-6	Installation spandrel part	lump sum	5.094 €		5.094 €		
	D-7	Sensors vision part	lump sum	4.140 €	-	4.140 €	7 - NSG1	Solar equipment facade, laptop weather station
	D-8	Sensors spandrel part	lump sum	5.366 €	-	5.366 €		

	D-9	Back up glass	m^2	1.979 €	8,73	17.275 €		
TOTAL ENVISION COSTS						**142.495 €**		
Other Costs not Covered by ENVISION budget	**F-1**	Frames: supplied by Wicona GmbH - Pirching 90, F-8200 Gleisdorf - Model Wictec 60				0 €	7 - NSG1	still missing, waiting for NSG feedback

With budgeting is meant typical cost of the demonstration. With this info (and later in the project) the energy gains, we wish to calculate in the future the ROI and applicability of this technology in the market.

4.4 Conclusions and lessons learnt

This Envision demo project is the first Pilkington **Sunplus™** project where Pilkington successfully scaled up their technology.

Below, remarks/experiences gained during the progress of this project are reported:

- *Preparations are intense and time consuming*
- *Transparent communication between all stakeholders is essential*
- *Subtle predictions shading effects (Turn-Tilt) Frames / and the environment of the Building*
- *Sophisticated lay out engineering – Fixation Junction boxes*
- *Challenging process to determine suitable solar equipment*
  - *High level of knowledge installer is needed. (Eko has this level)*
- *Complicated operational processes*
  - *Focus on no assumptions, training employees and checking/verify the agreements which have been made made is essential*
  - *Many different operational stages, labour intense.*
  - *Challenging to implement in automatic production lines*
- *Installation solar equipment is labour intensive because of complicated wiring*
- *Reliability suppliers is a point of attention (Solaria and Solarnova discontinued solar activities)*
- *Tiny Junction boxes with high level of reliability are expensive and scarce*

Next actions:

- *The Austria demo is nominated to become a "Living Lab" / commercial BIPV demo for NSG Pilkington Europe. From this site NSG/Pilkington will centralize the BIPV activities.*
- *NSG will focus on the next small demo: Pilkington Netherlands*
- *NSG will focus on the completion of the GTB Lab demo.*

5 Conclusions

After a few failed attempts to come to a good renovation for the Northern Demonstration there is a realistic plan for the renovation with the housing corporations Trudo and Compaen. The plan is to renovate 6 row dwellings with the Envision heat harvesting technology. The plan will be worked out in a renovation design specific for the selected houses. A significant advantage of the available row dwellings is the fact there is no approval required from the tenants.

The section of Southern Demo related to façade solar panels will be focused on the testing of ENVISON technology at District Level, in order to guarantee a high TRL. To do that, a proper design of the system is needed, and therefore, thanks to different small test cases of solar panels, it is possible to understand the best configuration of the system. The results in Savona showed that an installation of insulated panels, connected in series of 3 panels (from lighter to darker colour) could represent the best solution in order to optimize the panel performances. The available surface for the panel installation in Savona is around 90 m2, therefore the chance of installing several panels can be considered. The panels are expected to be installed in the first semester of 2021, therefore the last definition steps in order to have a proper system design are occurring.

In the demo for the Envision PV glass in Austria the technology was demonstrated successfully on a bigger scale. Different lesson were learnt during preparation and installation.

The different Envision technologies can be combined very well. Harvesting both heat and electricity from the façades and windows is an excellent combination especially when the available roof surface is limited. This is in particular the case for high-rise buildings. The closed façade surface can be used for heat harvesting panels, the windows for PV windows or ventilated windows. When the harvested heat is used as source for a heat pump electricity is required to run the heat pump. The harvested heat by the Envision heat collection panels and the ventilated windows are collected in a buffer and a heat pump can use this buffer as a source. This will result in high COP’s of a heat pump running on solar electricity.

Appendix – Budget demonstration case Plan A version 1

RAMING incl. ENVISION

Project: 00000, Delft - 24 appartementen
Overzicht bouwdelen:RA-04, Raming Vestia
Deelbegrotingen

Datum : 12-4-2019
Tijd : 09:15
Valuta : EUR

Deelbegr.	Omschrijving	Aantal project	Perc. deelname	Aantal deelname	Ehd	Deelbegroting excl. BTW	Offerteprijs excl. BTW	Offerteprijs incl. BTW
0200	- langsgevels + dak (NOM + onderhoud)	1		1,00	blo	1.779.310,71	1.779.310,71	2.148.194,60
0200A	- langsgevels + dak (Envision)	1		1,00	blo	693.558,48	693.558,48	839.205,76
0202	- kopgevel (NOM + onderhoud)	2		2,00	st	50.070,67	100.141,33	121.171,01
0202A	- kopgevel (Envision)	2		2,00	st	25.179,00	50.358,00	60.933,18
0203	- bouwplaatskosten op basis van 24 woningen	1		1,00	pst	223.388,73	223.388,73	269.997,74
0305	- bijkomende kosten	1		1,00	pst	105.853,63	105.853,63	128.082,89
Totaal:							**2.952.610,88**	**3.567.585,18**

The detailed budget is attached in “Raming RA-04 incl. Envision 20190412.pdf”

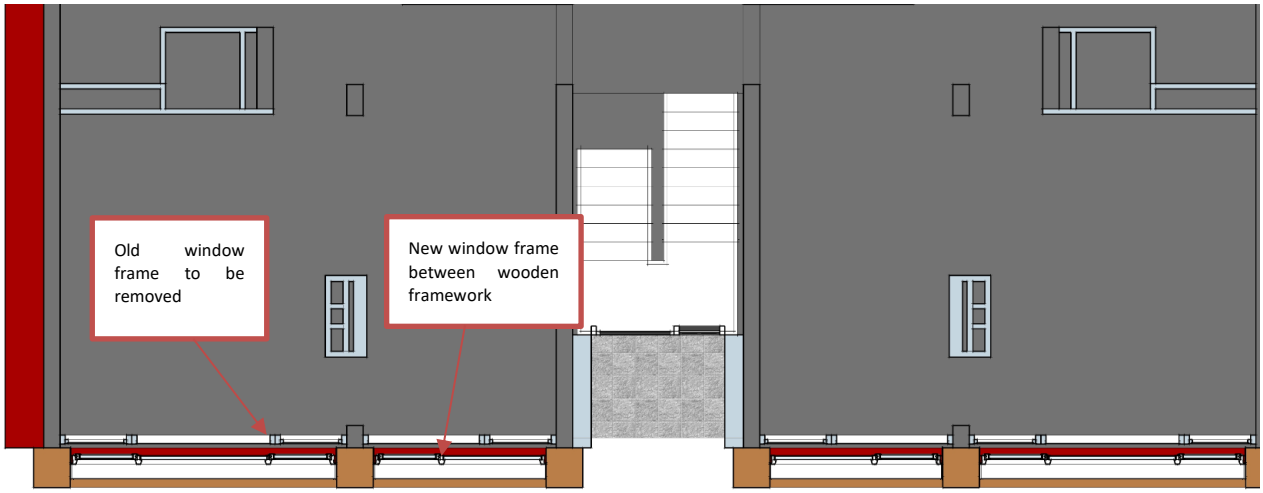
Appendix – Budget demonstration case Plan A version 2

Vestia budget	Sum total incl VAT
Bathrooms, Kitchens, Toilets	
Asbestos	
Indoor work	
	€ 629.200
Demolishing and egineering	
Fencing, demolishing	
BIM and engineering	
	€ 140.981
Insulation	
Windows frames etc.	
Insulation Northern facade	
Insulation Southern (left)	
Insulation Southern (mechanical mouting for contractor)	
Insulation Soutterain	
Insulation of Roof	
	€ 1.238.761
PV on roof	
PV	
	€ 62.726
Technical installation budget for contractor	
Ventilation system (heat recovery)	
Connecting installation drilling etc. needed by contractor	
Heat Exchanger / installation drilling needed by contractor	
Painting outside (lower part of building)	
	€ 213.072
Bouwplaatskosten	
Algemene kosten	
Winst en Risico	
CAR verzekering	
VAT (21%)	€ 452.379
Total for Vestia incl. VAT	€ 2.737.119
Total incl VAT per appartment	€ 114.047
ENVISION	
Complete installation (till appartments) - Vestiabudget (excl. VAT)	
Coordination costs contractor (excl. VAT)	
AkzoNobel (panel production)	
Prefab wooden skeleton (south, end facade, excl. North)	
Panels	
Advisory costs	
Control strategy for installer	
	€ 1.250.910
Total	€ 3.988.029

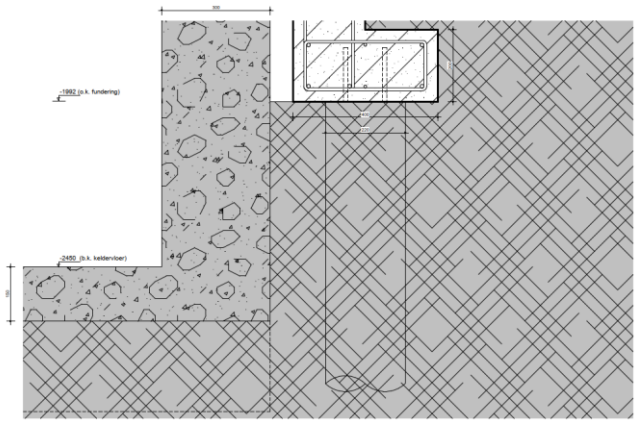
Appendix – Budget demonstration case Plan B - Pagedal

Subjects	Estimated costs
Insulation floors	€ 30.000
Insulation facades	€ 27.000
New window frames	€ 183.000
Standard renovation measures	**€ 240.000**
Envision heat harvesting panels including installations	€ 360.000
Roof Solution including prefabricated construction elements and integrated solar panels	**€ 750.000**
Envision renovation solution	**€ 1.110.000**
Total estimate	**€ 1.350.000**

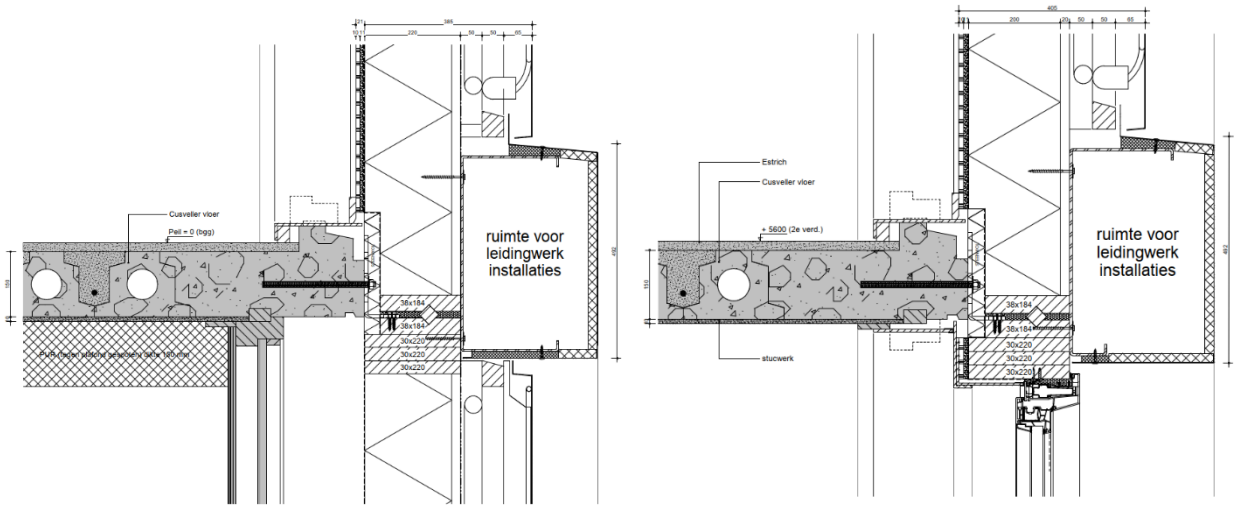
Appendix – Construction principles Plan A version 1



Foundation of wooden framework on piles (cross-sectional view from above – ground floor)

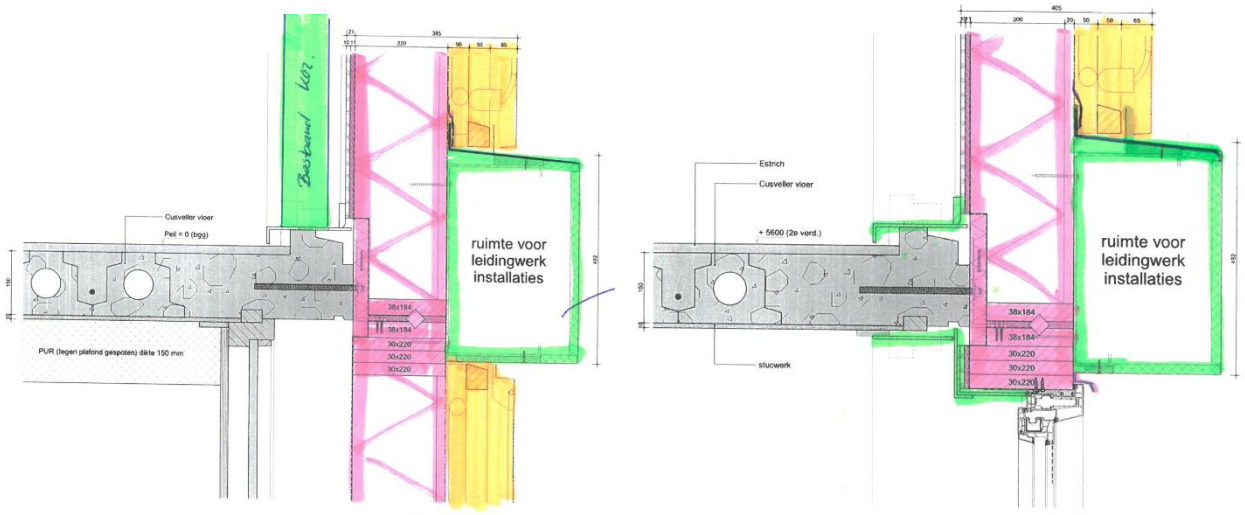


Foundation of wooden framework on piles

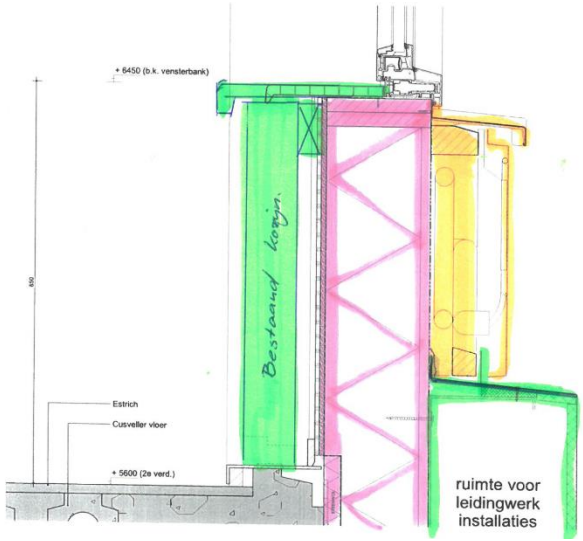


Insulating elements, heat harvesting modules and window frames between the wooden frame work (cross-sectional view from side)

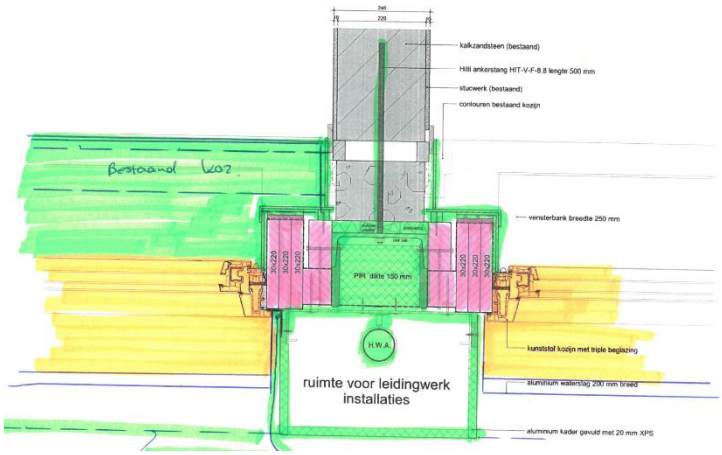
Appendix – Construction principles Plan A version 2



Insulating elements and heat collection modules mounted on actual floor (cross-sectional view from side)



Insulating elements and heat collection modules below windows (cross-sectional view from side)



Provision for the piping of the heat collection modules in vertical direction between the two windows of two different apartments (cross-sectional view in vertical direction)

Appendix – Gant chart Plan C