D5.2 – Baseline reports of pre-renovation condition of demonstration case

WP5

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Executive Summary

The baseline report of pre-renovation is crucial for the accurately determination of the baseline performances of the following Envision demonstrators: Savona Campus demonstrator, Delft apartment building and Pilkington's office building demonstrator. Each of them have specific features aimed to the evaluation of different aspects of the performances. According to the expectations, from each demonstrator we will calculate the KPIs, as given in D5.1.

From the Savona Campus it is expected to evaluate the performance of the bi-directional heat exchange between the building and the low temperature district heating. Evaluation of the Mechanical Electrical Plumbing (MEP) system integration and coupling with ENVISION technologies is also a characterising element of the demo.

From the three - story apartment building in Delft, major contribution is expected on the coupling between a real case study and the impact for the tenants.

In the Pilkington demonstrator the main objective is to evaluate the photovoltaic performances of the PV triple glazing (a unique product which will be demonstrated in the world for the first time) and, with appropriate extrapolation methods, transfer the replication to all the European countries.

At this stage of the project, not all the baseline information is available at this moment, as the buildings are still being monitored (or are not monitored before at all). This monitoring data, e.g. the Vestia building is currently being monitored since February 2019, will be included in the deliverable D 5.3.

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Abbreviations and Acronyms

[ATO] – Antimony-doped Tin Oxide

[BIPV] – Building Integrated Photovoltaic

[CR] – Concentration Ratio

[DHN] – District Heating Network

[HVAC] – Heating Ventilation Air Conditioning

[IGU] – Insulated Glass Unit

[IESL] – Innovative Energy System Laboratory

[mGT] – micro Gas Turbine

[NIR] – Near Infrared Reflectance

[PVB] – PolyVinilButiral

[SEAC] – Solar Energy Application Centre

[SPM] – Smart Polygeneration Microgrid

[TRL] – Technology Readiness Level

[TSA] – Total Solar Absorbance

1 Introduction

1.1 Goals and scope of this report

Important part of the Envision project is measuring the improvement thanks to the applied techniques at the demonstration sites. In order to do that an inventory must be made of the pre-existing situation.

For the comparison of the situations at the demonstration sites before and after extended lists of KPI's are shown in tables 2 and 4 in this document.

It is mentioned throughout the report, that not all data are available up front. Some are depending on the cooperation of tenants, because of the restrictions of privacy regulations, recently implemented.

This is a live document, which will be completed with additional information as soon as available. We must understand and accept, that measuring instruments with modern technology, that will be installed to assess the situation after the renovation were not installed at all demo sites before Envision. Some did not even exist at the moment.

The goals of this report are to collect as many data as possible in order to get insight of the base situation of the demonstration sites. The scope is indicated by the list of KPI's.

1.2 Demonstration sites

1.2.1 Savona Campus

Demonstrator in Savona campus has a critical role, especially for the evaluation of the district heating performances. In particular, the main objective of this demonstrator is to evaluate the bi-directional heat exchange between a new concept of Envision building and the district heating generation grid.

For this scope, all the thermophysical variables will be monitored: from the heat generation trough the Envision panels to the liquid flow in the heat exchangers.

The foreseen outcome will be in terms of minimum harvesting surfaces needed under certain conditions of solar radiation to obtains the best energy balance optimization.

1.2.2 Delft demonstrator

This document is created to give an overview of the Vestia Demo Site conditions in Delft. This document contains the baseline assessment in which is stated what the location is of the demo site, the construction specifications and building characteristics. Section two explains more about the new situation. The description of the new situation appoints the changes for the building specifications of specific retrofit choices. In this document, the KPI's are measured before installation. Not all of them can be measured yet, therefore, the monitoring data needed and the assessment of the KPI's will be included in D5.3. Which means that the KPI's, energy system decision and calculation of the costs will be added when more and sufficient information is available.

1.2.3 Pilkington demonstrator

The Pilkington's demonstrator has the key importance in terms of the photovoltaic technologies performance evaluation. The outcome of the energy productions monitoring, will be used as input in the energy model to determine the energy balance of the building. The different contemporary factor between the energy demand and photovoltaic production will be treated as smart grid concept.

2 Savona campus

2.1 Building description

For what concerns the “Polygeneration Microgrid Test-Rig”, the main aims of the panel installation are the testing of the correlation between the panel performance and the outdoor conditions (solar irradiation and wind speed and direction) and their integration with the district heating local network. Therefore the evaluation of the building indoor conditions is not mandatory.

It is under consideration the possibility of installing an “indoor conditions sensor” in order to evaluate how the warm water flow through the panels pipelines (close to the building wall) could affect the indoor ambient features (indoor temperature and humidity related to the outdoor conditions).

The final decision depends on the façade panel design for this installation that is in progress.

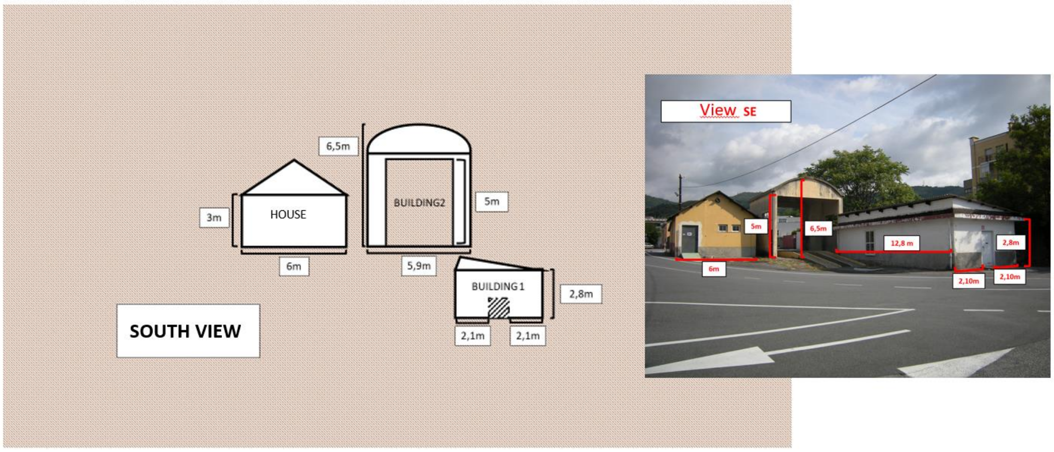


Figure 1 The Polygeneration Microgrid test-rig area

Figure 1 shows a view of the present state of ENVISION test rig area. The building chosen for panels installation is the so called “building 1”, while the “building 2” will be used for the mGT and Heat pump installation as shown in the rendering of Figure 2. “building 1” orientation is shown in Figure 2.

Figure 2 The Polygeneration Microgrid test-rig rendering

It must be noticed that in Figure 2 the panels are applied only on one surface, but in the real application they will be applied on all the building vertical surfaces.

For what concerns the ventilated windows test rig, the chosen place in the beginning is one of the office in Delfino building, as in Figure 3. The window has a South orientation, therefore heat capture is optimized.

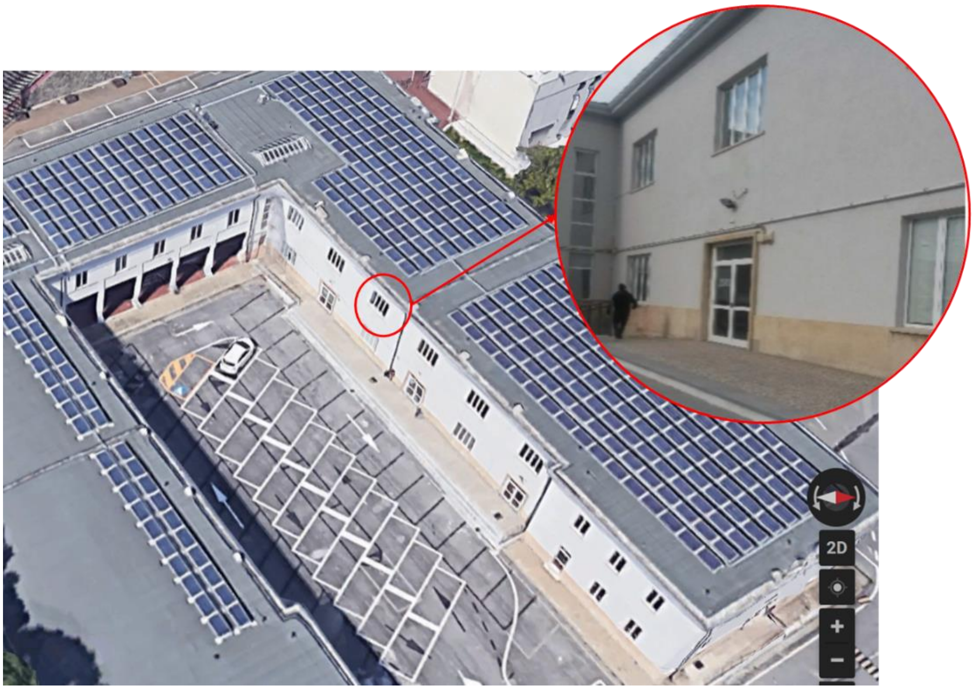


Figure 3 Delfino office outside detail for ventilated windows installation

The office has a conditioned environment in its inside, with a room size of around 30 m^2 where usually only one person works during common office working time. In order to evaluate the window performances, a "twin office" with the same dimensions will be used for a comparison with the ventilated window room performances. it is very relevant that the possibility of a hot water circuit requirement, in case of a ventilated window configuration with a heat exchanger, could lead to the necessity to find a new installation place inside the Campus where a water circuit is available. In the next months, when BGTech will perform more tests on their prototype, the provided info will lead to find the installation place that can comply both UGT and BGTech requirements.

2.1.1 MEP system description

The Polygenration Microgrid test-rig is designed as in Figure 4. It consists into two branches connected in parallel: one with a 100 kW micro Gas Turbine that supplies an high amount of thermal energy and another one with an heat pump that uses, as cold source, the heat from the panels. The heat pump is installed in order to guarantee that the fluid tempertature in the outlet of ENVISION test rig is around 75 °C, indeed this is the reference temperature for the District Heating Network (DHN). The return temperature from the DHN is estimated to be around 55°C. indeed, the inlet water temperature of façade panels circuit is expected to be around 20-25°C with an outlet temperature that will depend on panels performances and connections (series or parallel). Thanks to the use of controlled thermal dissipators, it will be possible to have one degree of freedom in the temperature sets.

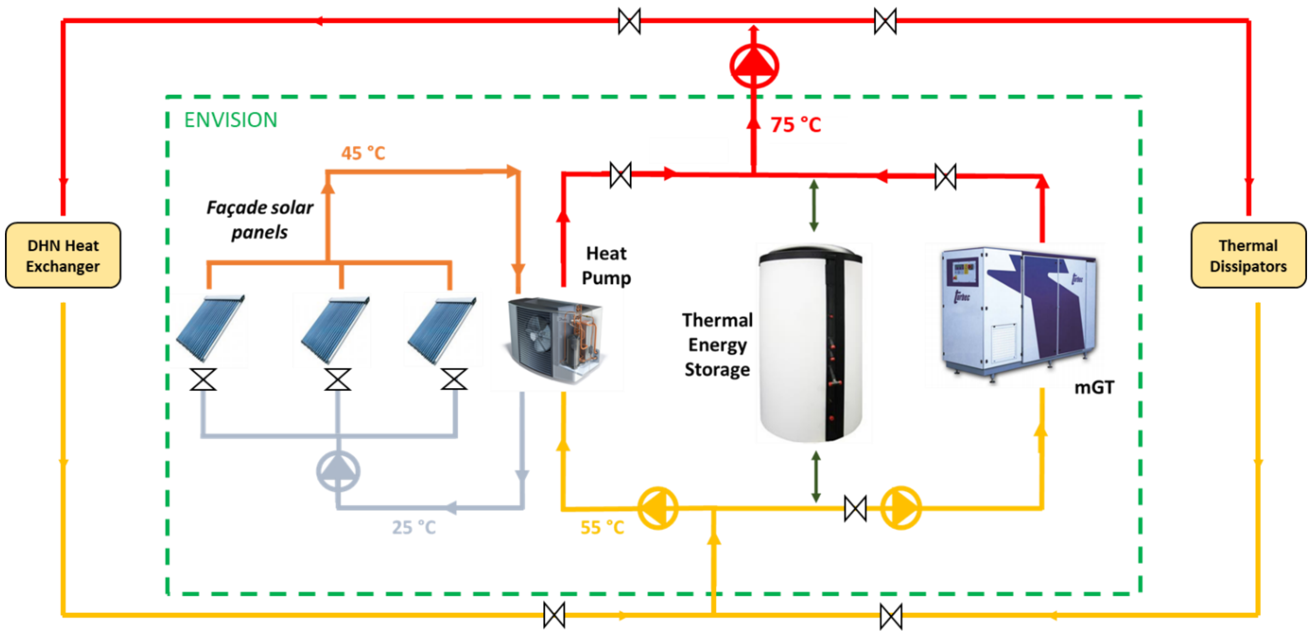


Figure 4 Schematic diagram of the Polygeneration Microgrid test-rig

For what concerns the ventilated windows the main set point is the room temperature and environmental conditions. During the cold period the air warmed passing through the window glasses is directly blown inside the room in order to heat the room ambient. During the hot period, BGTech is examining the possibility to blow fresh air inside the room using a heat exchanger air-water that could also provide hot water to users. In case of positive response from BGTech studies on this configuration with heat-exchanger, ventilated windows will be placed in a different location inside Savona Campus, where a water circuit is available.

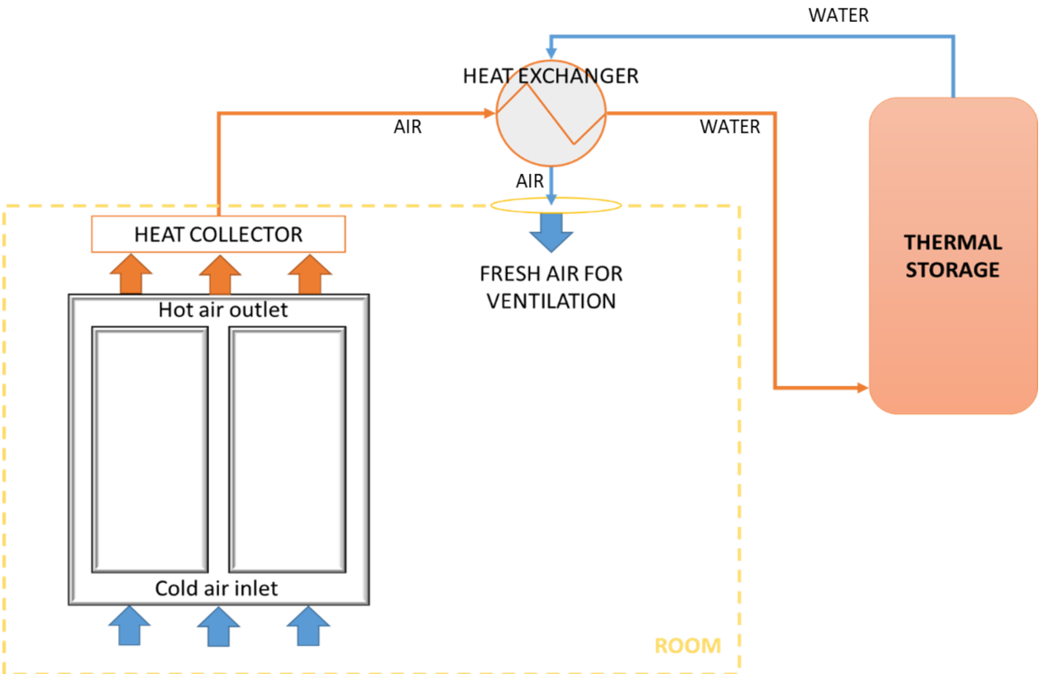


Figure 5 Schematic diagram of ventilated windows test-rig

2.2 Weather Data Analysis

2.2.1 Outdoor air temperature

In the the outdoor air temperature is directly monitored and the data are sampled and saved every 10 minutes on the so called "Campus Data server". A wide data collection is already present and the measure campaign will continue also during ENVISION technologies installation and tests.

Figure 6 shows the temperature trend throughout the 2016.

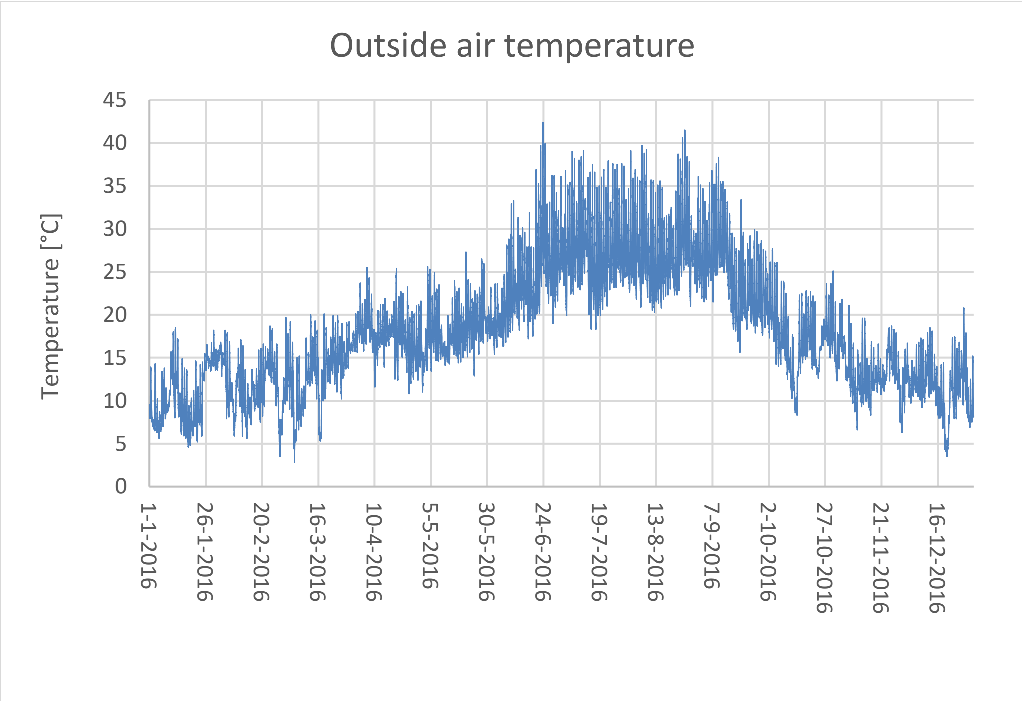


Figure 6 Outside air temperature annual based in Savona Campus

Is it possible to see the temperature variation depending on different seasons. The hot summers have temperatures between 20 and 40 °C during an entire day, while in the coldest months the temperatures decrease to a range between 0 and 20°C. The main temperature data are reported in Table 1.

Table 1 Outside temperature data referred to 2016

Significant outside air temperature data	
Avg. Temperature [°C]	17.9
Min Temperature [°C]	2.8
Max Temperature [°C]	42.4

2.2.2 Humidity Ratio

These data are not directly measured in the Savona Campus. All the available data are given by "ARPAL " (Agenzia Regionale per la Protezione dell'Ambiente Ligure). ARPAL is a public organization that supervises Local area in terms of ambient and territory conditions. The Humidity ratio given by this "centralized" unit could also be used for evaluating this parameter at Savona Campus. If necessary, an added humidity sensor could be installed to have more accurate data.

2.2.3 Solar radiation

As explained for the outdoor air temperature, the "Campus Data server" in Savona Campus collects also data about the Solar Radiation. These data are sampled every minute in a continuous measure campaign, therefore a huge data collection is available for this value. The Solar radiation sensor is installed on the roof of the "Delfino building" (close to the ENVISION-Demo site area, see Figure 7), therefore no shadows are present in this area.

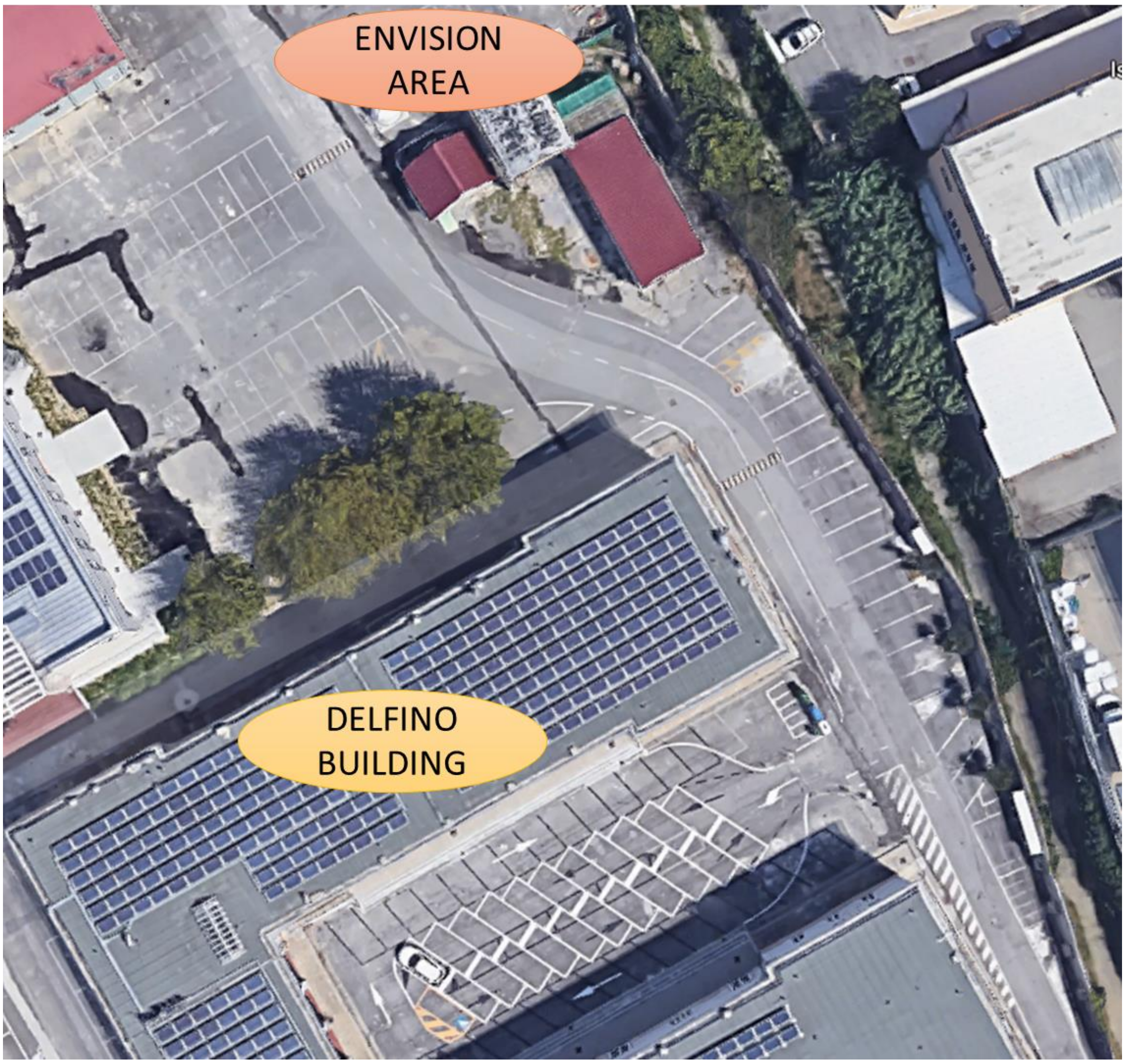


Figure 7 View of the involved area for ENVISION installation and radiation measures

Similarly to the outdoor air temperature, Figure 8 shows the solar radiation throughout the entire year 2016 with a sample time of one minute. The figure is not very clear and detailed because of the large amount of data, but can give a good overview of the peak values during the year (the maximum value is around 1400 W/m^2). As reference, three "example days" of cold, hot and warm periods have been considered; from Figure 9, Figure 10 and Figure 11 it is possible to see the radiation behaviour on daily base. It can be considered that, moving from cold to hot periods, the solar radiation peak and the solar exposition period get higher.

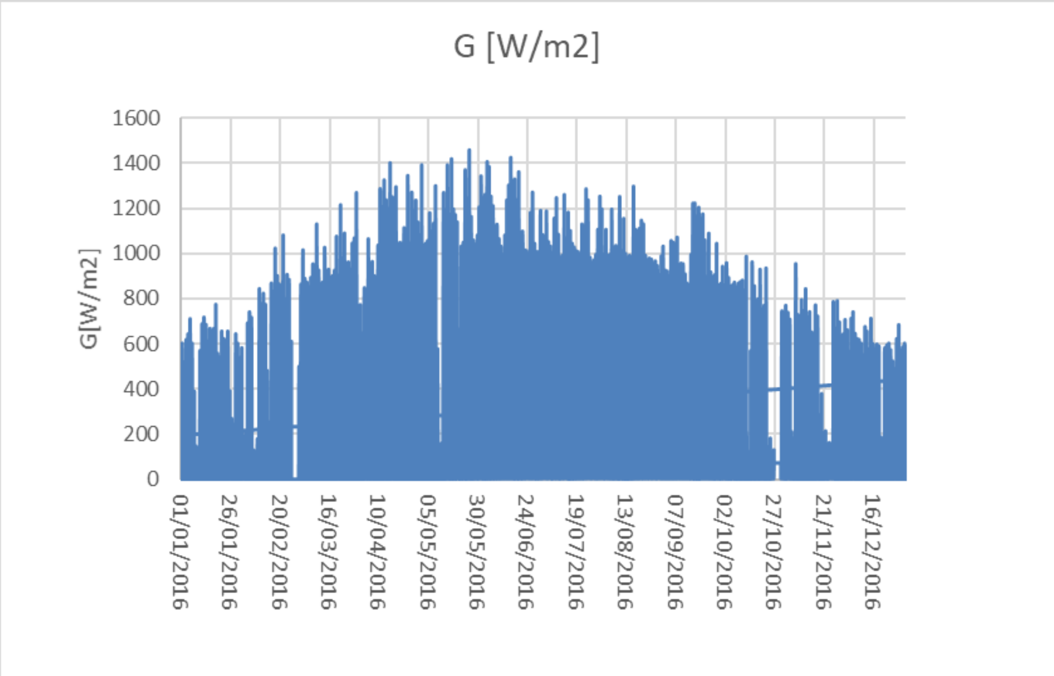


Figure 8 Solar radiation annual based in Savona Campus for 2016

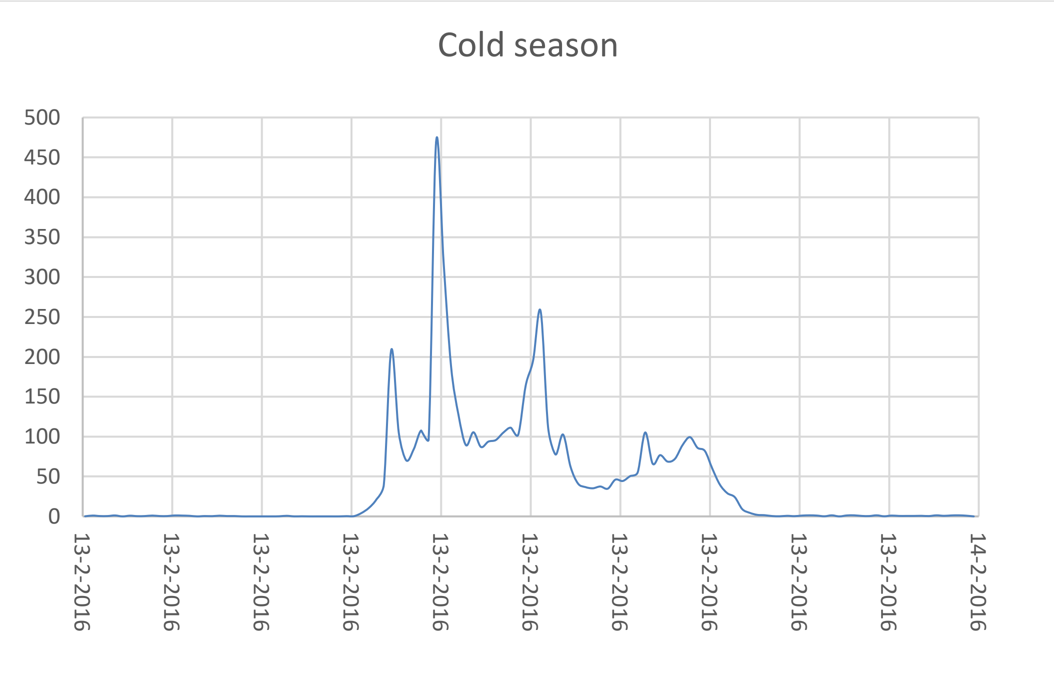


Figure 9 Solar radiation at Savona Campus in a cold season day of 2016

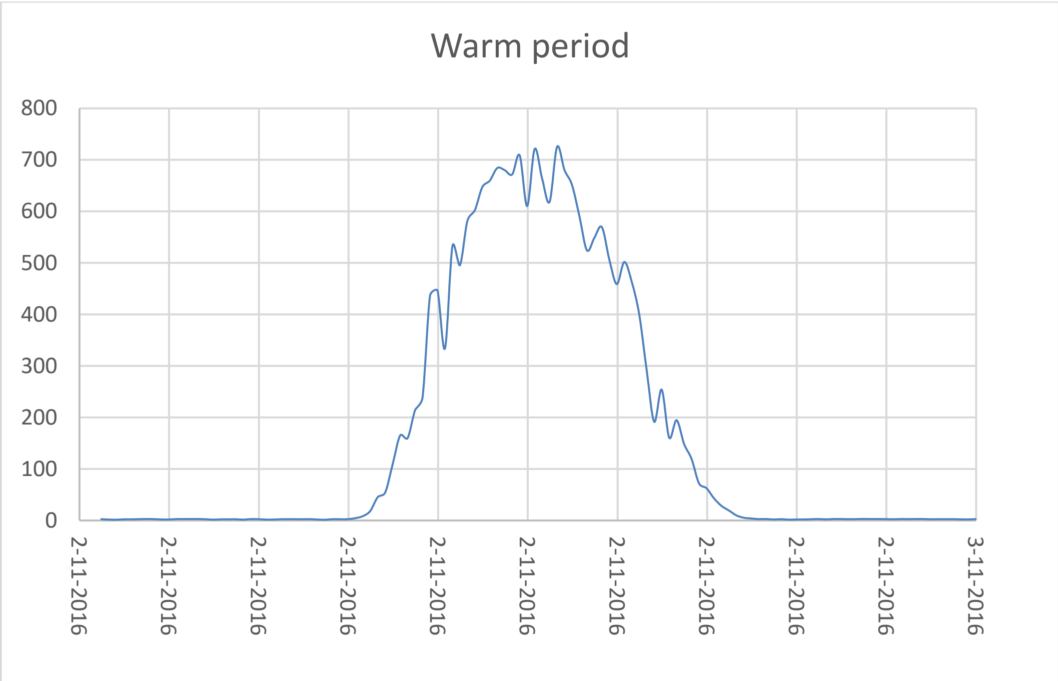


Figure 10 Solar radiation at Savona Campus in a warm period day of 2016

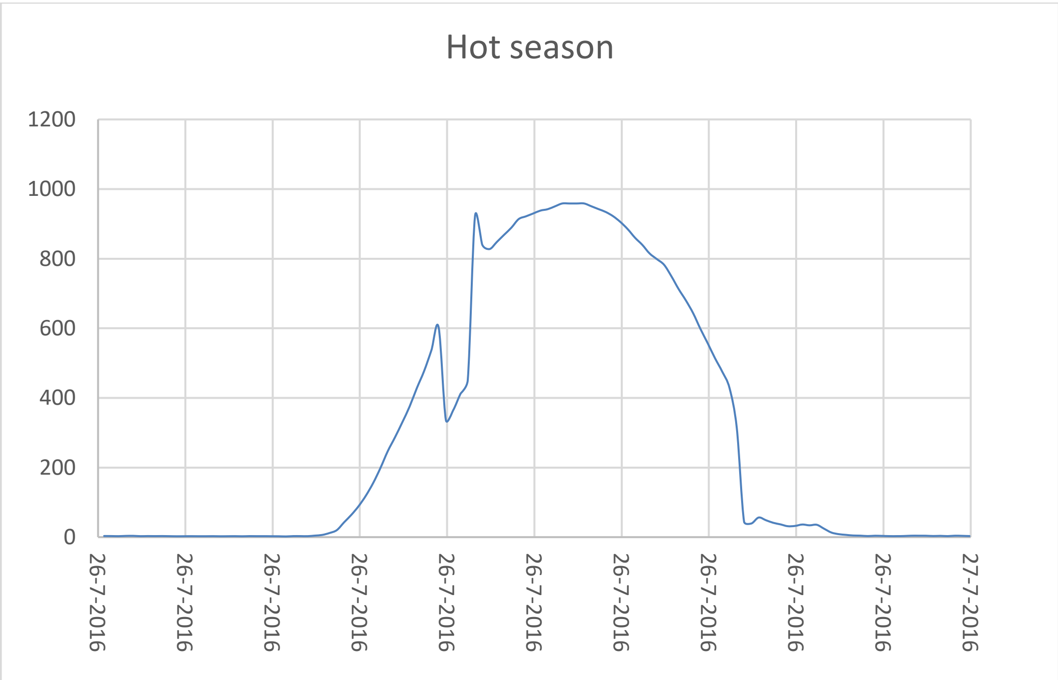


Figure 11 Solar radiation at Savona Campus in a hot season day of 2016

2.2.4 Wind direction/intensity

As explained for the Humidity ratio, data about wind direction and intensity are not measured directly in the Savona Campus but all the available data are supplied by ARPAL. It must be considered that wind measures could be significantly affected by the geographical position; therefore a “centralized” measure could not be representative of what happens in ENVISION test rigs inside Savona Campus. Indeed, other buildings and constructions around our test rigs have an impact on wind intensity and direction actually experimented in test rig areas. It will be considered therefore the necessity of a dedicated sensor in ENVISION areas.

2.3 Baseline Energy Monitoring

At this project phase UGT is defining all the installation on site. No baseline measurements are foreseen. In the following paragraphs the updates of the monitoring equipment's installations and the plant configurations will be showed.

2.3.1 Polygeneration Microgrid Test-Rig

For what concerns the Polygeneration Microgrid Test-rig an evaluation of technologies performances, related to ambient conditions and control strategies, will be achieved. Indeed, different parameters could affect the façade panel behaviour. temperature, wind direction and intensity, weather conditions are parameters that will be correlated with the panels performances evaluated during the tests. Also the control strategy could affect significantly the panel performances; the possibility to set a mass flow control in order to have a required temperature in panels outlet, or to work with a fixed mass flow having therefore different temperatures in panels outlet, could significantly change the panels behaviour.
The panel impact on the Savona Campus is performed by simulation: the tested panel performance will be scaled up to a size close to the total amount of available vertical surfaces inside the campus in order to understand their impact on the District Heating Network (DHN) with a comparable scale. In a small scale, the presence of a Cogenerative Heat Power unit (the micro Gas Turbine) could act as a small DHN where the users demand are the controlled Fan coolers already available in the laboratory. Therefore this approach guarantees three levels of test campaigns: the first one focused on technologies performance evaluation, the second one allows to understand the impact on a real DHN on a simulation level, the third one instead gives the opportunity to actually test ENVISION technologies impact on a comparable size District Heating Network.

The use of façade modules allows exploiting a wider range of Near Infra-Red (NIR) solar irradiation and leads to a building renovation thanks to the different colours available.

The available surface for façade modules is around 100 m^2 and, considering the energy harvesting around 1.5 GJ/m^2 per year (as estimated in ENVISION proposal), the heat power in output will be used to supply the buildings thermal demand through the DHN. A thermal storage will be used in order to optimize the system management.

The ENVISION tecnologies will be tested considering the connection to the District Heating Network and the intagration with an heap pump, a cogeneration system (micro gas turbine) and two thermal storages .

In order to evaluate the panel and system performances and to define the proper control strategy, different measures need to be taken. The most important performance parameters are **heat exchanged, temperatures, pressure drops, electrical generation and electrical consumption.**

Heat flow is one of the most important system parameters.
The point where it will be evaluated are:

- Façade solar panels
- Heat pump cold side
- Heat pump hot side
- Micro Gas Turbine

In order to measure the heat flow, it is necessary to evaluate temperature and mass flow values. Then the heat flow will be obtained as in (1)

$$\dot{Q} = \dot{m} * c_p * (T_{out} - T_{in}) \tag{1}$$

Where c_p is the specific heat for the considered fluid, in this case water (with a small percentage of glycol). Therefore, temperatures and mass flow sensors need to be installed for heat transfer evaluation and their measures will be processed using LabView software. If further info are needed, a more detailed description of measures campaign is provided in ENVISION D5.1.

outdoor ambient conditions will be evaluated by the central monitoring system in Savona Campus.

2.3.2 Ventilated windows test-rig

The ventilated window is tested in terms of its impact on indoor ambient conditions. Therefore a "comparison room" will be used to have parameters to compare with the ones obtained inside the "ventilated window room". If it will not be possible to have two room available for our measure campaign, it could be considered the option to evaluate the indoor conditions of the same room in a before and during the ventilated window installation (for example on annual base).

Considering the summer configuration of the ventilated window (with the heat exchanger installation), it will be necessary to evaluate the system performance in terms of heat produced; therefore, as explained for the façade panels, measures of mass flows and temperatures will be provided in order to evaluate the amount of hot water and fresh air produced.

2.3.3 Complete list of sensors/meters

It is supposed that pressure drops are the same for each panel, therefore mass flow rates and pressure drops are measured once for all the panels. Another estimation is done in terms of orientation: only one panel type will be compared in terms of orientation, scaling the differences found for the other types.

With this configuration the sensors list for ENVISION section is:

- (1x temperature meter placed in inlet of the sample panel kind) x 4 orientations + (1x temperature meter placed in inlet of each panel kind) x (N° of panel kinds – 1)
- (1x temperature meter placed in outlet of the sample panel kind) x 4 orientations + (1x temperature meter placed in outlet of each panel kind) x (N° of panel kinds – 1)
- 1x pressure sensor + 1x mass flow meter in inlet of the panels ramification
- 1x pressure sensor + 1x mass flow meter in outlet of the panels ramification
- 1x temperature meter placed in inlet of the heat pump cold side
- 1x temperature meter placed in outlet of the heat pump cold side

TOTAL AMOUNT considering 3 kinds of panel:

- 14x temperature meters
- 2x mass flow meters
- 2x pressure sensors

In order to evaluate the panel performances, the surface temperatures will be measured. For a good measurement campaign the surface temperatures will be measured once for each panel type, then for a chosen colour the surface temperature will be evaluated also in different orientation.
Therefore ***6 more temperature meters*** will be necessary for surface panel temperature measurements.

For what concerns the main circuit (the one that could lead to District Heating Network or Controlled thermal dissipators), the number of installed sensors can be easily determined.
The mass flow is evaluated after the main circuit ramification and in one of its two branches (on the other branch, it is calculated as difference from two others). The temperature is then calculated in inlet and outlet of main circuit ramification. In addition, for systems performance evaluation, temperatures are also measured in inlet and in outlet of mGT and heat pump.

TOTAL AMOUNT:

- 2x mass flow meters
- 6x temperature meters

The test rig placed at the University of Genoa Savona Campus can be considered as a cogenerative system able to produce both thermal and electrical power. Therefore, the amount of produced electrical energy needs to be evaluated to understand the system behaviour. The responsible component of electrical energy generation is the micro-Gas Turbine. This component already provides a monitoring system for electrical generation; therefore no additional sensors will be installed.

For what concerns electrical energy consumption, the systems needs recirculation pumps to guarantee an uniform fluid flow. Heat pump is also installed in order to reach the temperature requirements (about 75°C) of District heating Network after pre-heating through façade panels. Electrical energy consumed by these systems will be directly or indirectly evaluated considering the overall energetic balance of the system.

Moreover, the installed heat pump will be a prototype unit with some modifications proposed by the University of Genoa in order to increase the coefficient of performance (COP) of this component.

Figure 12 shows the measuring system for the Polygeneration Microgrid test-rig with the various point where it is expected to place the sensors.

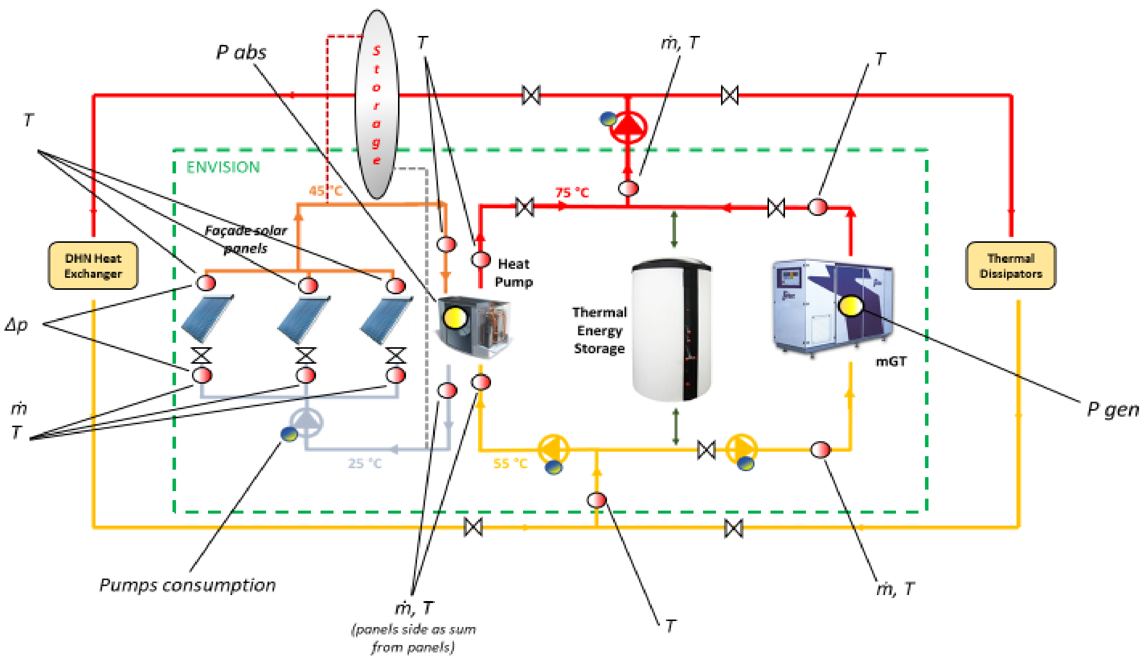


Figure 12 Plant system and measured point for Polygeneration Microgrid test-rig

Regarding the ventilated windows, the winter configuration needs only a room temperature and humidity measures. Therefore **2 sensors for humidity and temperature** are necessary (one for the "ventilated window room" and the other for the comparison room). A possible solution for this sensor could be the one shown in Figure 13 with its technical specifications in Figure 14, a remote data saving is required.

Figure 13 Indoor temperature and humidity sensor

Technical specifications

CO_2 measurement	
Measuring principle	Non-diffusive infrared (NDIR) technology
Type of sensor	Double-beam infrared cell sensor
Measurement range	0 to 5,000 ppm
Uncertainty	± 50 ppm ± 3 % of value measured
Response time, 63 %	< 200 seconds
Resolution	1 ppm
Temperature measurement	
Type of sensor	CMOS
measurement range	-10 °C to +60 °C
Accuracy	± 0.5 °C
Resolution	0.1 °C
Humidity measurement	
Type of sensor	Capacitive
Measurement range	5 to 95 % RH
Accuracy	± 2 % RH
Resolution	0.1 % RH

Types of use	
Point measurement Monitoring	Quick measurement and display of the CO_2, temperature and relative humidity values
Monitoring	**1D mode**: indication of CO_2 confinement Visual (two-colour backlighting & pictograms) and/or audible indication of high confinement when the CO_2 concentration is between 1,000 ppm and a 1,700 ppm threshold. **3D mode**: indication of optimum comfort zone on the basis of the hygrothermal criteria and the CO_2 concentration.
	Energy-saving (ECO): for fixed use on battery power, the product performs measurements every 10 minutes over a programmable time range for a battery life of up to one year.
Logger	Triggering of programmed recording (P_REC) The start date, recording rate and end date can be customized with the PC software or the Android application. Possibility of locking the display in this mode (no values displayed). Manual triggering (M_REC) Manual start and stop controls on the product. Recording is performed at the rate of the mode currently selected.

Specifications	
Recording interval	Customizable from 1 minute to 2 hours
Storage	More than 1 million measurements
Buzzer	Yes
Units	°C or °F
Backlighting Display Hold function Min-Max	Yes
Automatic power-off	Yes (in portable mode only)
General specifications	
Product operating range	Temperature: -10 °C to +60 ° C – Humidity: 5 to 95 %RH
Dimensions / weight	125 x 65.5 x 32 mm / 190 g with batteries
Protection	IP40
Compliance	IEC 61010-1 for 50 V in Category II – IEC 61326-1 – Compliance with French decree no. 2012-14
Power supply	- Alkaline batteries: 2 x 1.5 V AA / LR6 or rechargeable battery - Connection to mains possible with mains / micro USB adapter supplied as standard
Interfaces	2 communication modes possible: - Bluetooth wireless communication - USB link; the product is then recognized as a USB key for easy file transfer
Mounting	C.A 1510 casing equipped with a magnet, a wall-suspension system and a slot for hanging the product. A wall support for use with a padlock (padlock not supplied) is available as an accessory, as is a desktop stand (supplied as standard with the C.A 1510W).
Functions of the AQR (Air Quality Report) software supplied as standard	Graphic representation or as table of values – Data export – Real-time mode Calculation of the confinement index with selection of presence periods – Report generation

Figure 14 Indoor temperature and Humidity probe technical specifications

If also the summer configuration will be performed, installing the heat exchanger, measures of temperature and mass flow rate will be necessary to evaluate the system performances. The measure campaign will lead to install **4 temperatures probes** and **2 mass flow meters** as shown in Figure 15.

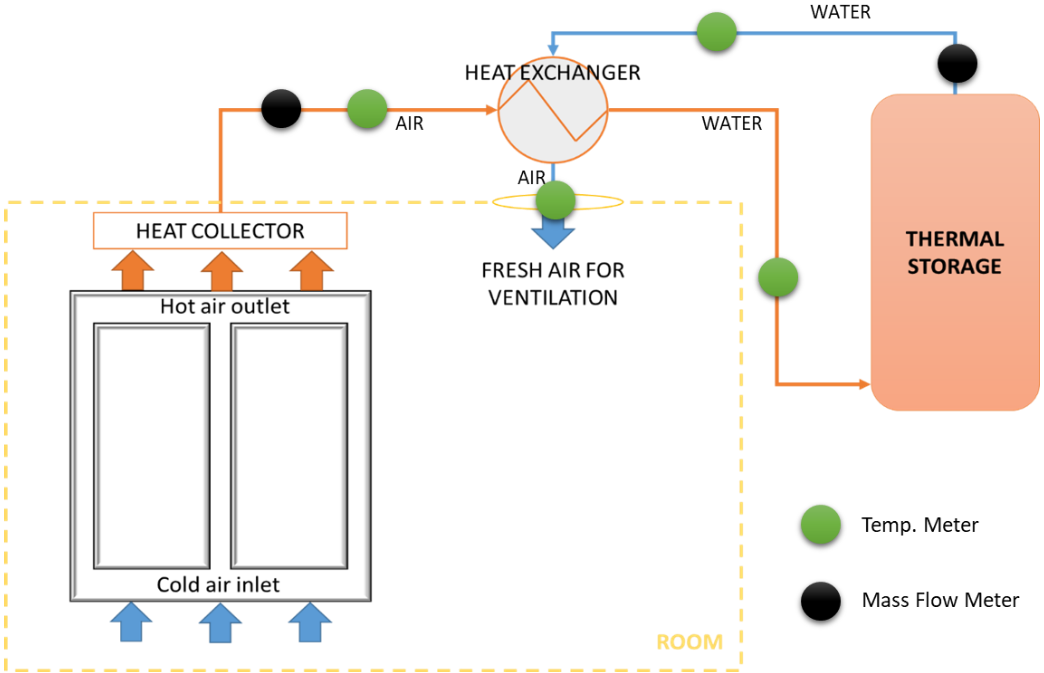


Figure 15 Plant system and measured point for ventilated windows test-rig

The air mass flow meter for this application could be one like what is shown in Figure 16 with its technical specifications reported in Figure 17.

Figure 16 Air mass flow meter

Mass Flow Meters (MFM); PN100 (pressure rating 100 bar)

Model	min. flow	max. flow
F-110C	0,014…0,7 ml_n/min	0,06…9 ml_n/min
F-111B	0,16…8 ml_n/min	0,16…25 l_n/min
F-111AC	0,4…20 l_n/min	0,6…100 l_n/min
F-112AC	0,8…40 l_n/min	1,4…250 l_n/min
F-113AC	4…200 l_n/min	8…1670 l_n/min

Measurement / control system

Accuracy (incl. linearity)	: standard: ±0,5% Rd plus ±0,1%FS
(based on actual calibration)	±0,8% Rd plus ±0,2% FS for F-110C-005/F-200CV-005
	±2% FS for F-110C-002/F-200CV-002
Turndown	: 1 : 50 (in digital mode up to 1:187,5)
Repeatability	: < 0,2% Rd
Settling time (controller)	: standard: 1…2 seconds
	option: down to 500 msec
Control stability	: < ±0,1% FS (typical for 1 l_n/min N_2)
Operating temperature	: -10…+70°C
Temperature sensitivity	: zero: < 0,05% FS/°C; span: < 0,05% Rd/°C
Pressure sensitivity	: 0,1% Rd/bar typical N_2; 0,01% Rd/bar typical H_2
Leak integrity, outboard	: tested < 2 x 10^{-9} mbar l/s He
Attitude sensitivity	: max. error at 90° off horizontal 0,2%
	at 1 bar, typical N_2
Warm-up time	: 30 min. for optimum accuracy
	2 min. for accuracy ± 2% FS

Mechanical parts

Material (wetted parts)	: stainless steel 316L or comparable
Process connections	: compression type or face seal couplings
Seals	: standard: Viton®;
	options: EPDM, Kalrez® (FFKM)
Ingress protection (housing)	: IP40

Electrical properties

Power supply		: +15…24 Vdc		
Max. power consumption		: Supply	at voltage I/O	at current I/O
	Meter:	15 V	95 mA	125 mA
		24 V	65 mA	85 mA
	Controller:	15 V	290 mA	320 mA
		24 V	200 mA	215 mA
Extra for fieldbus:	PROFIBUS DP:	add 53 mA (at 15 V) or 30 mA (at 24 V)		
(if applicable)	EtherCAT®	: add 66 mA (at 15 V) or 41 mA (at 24 V)		
	PROFINET	: add 77 mA (15 V supply) or 48 mA (24 V supply)		
	DeviceNet™:	add 48 mA (at 24 V)		
Analog output/command		: 0…5 (10) Vdc or 0 (4)…20 mA		
		(sourcing output)		
Digital communication		: standard: RS232		
		options: PROFIBUS DP, DeviceNet™, EtherCAT®,		
		Modbus-RTU/ASCII, PROFINET, FLOW-BUS		

Figure 17 Air mass flow meter Technical specification

A detailed presentation of all the other probes that will be used in the measure campaign can be found in ENVISION Deliverable D5.1.

2.4 KPIs

With reference to the APPENDIX C of the D5.1 "KPIs plan for monitoring and assessment of the technologies at demo site levels"; at this stage (Baseline), no KPIs will be calculated for the Savona Campus.

In order to provide an overview, the complete KPIs list are following reported:

Name of demonstrator	KPI type	Progressive number	Design stage
Sa	Thr	1	P
Sa	Thr	2	P
Sa	Thr	3	P
Sa	Elc	1	P
Sa	Elc	3	P

Table 2 - Savona Campus Generic KPIs – Post Renovation

Name of demonstrator	KPI type	Progressive number	Design stage
Sa	COP/EER	1	P
Sa	Solar_Eff	1	P
Sa	Storage_losses	1	P
Sa	DH_th_exchange	1	P
Sa	DH Substation_Eff	1	P
Sa	DH heating_cycles	1	P
Sa	PV_Eff	1	P

Table 3 - Savona Campus Specific KPIs – Post Renovation

Considering that the Savona Campus demonstrator does not have energy consumptions in baseline stage, the KPIs will be calculated after installation and the actual performance is measured and included in the deliverable 5.3.

3 Delft Demonstrator

3.1 Building description

The building is located in Delft (Vosmaerstraat), the Netherlands. This location consists of a three story apartment building with 24 units on four stairwells, built in 1955. The apartments average surface is about 70 m². The length of the building is 66.02 meters with a width of 11.00 meters. The total plant of the demo site is 726.22 m².

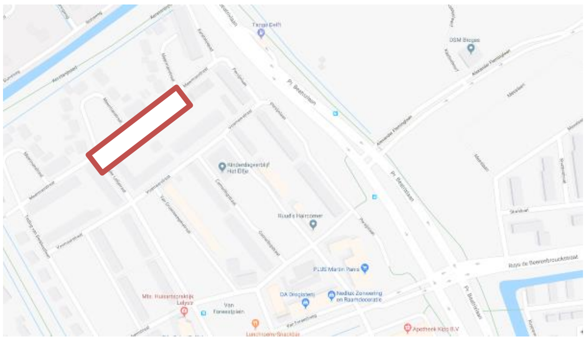


Figure 1. location of the apartments within Delft

The front façade is oriented towards the South-east and has- except for some trees on a distance variation from 4 to 12 meters- hardly any shadow from adjacent buildings, which makes it suitable for the elements of the Envision project. The back façade faces North-west, which means that hardly any sunlight will be caught on this side. The four stairwells have stacked glass windows at the back façade and cover the full width and height of the façade, see Figure 3.

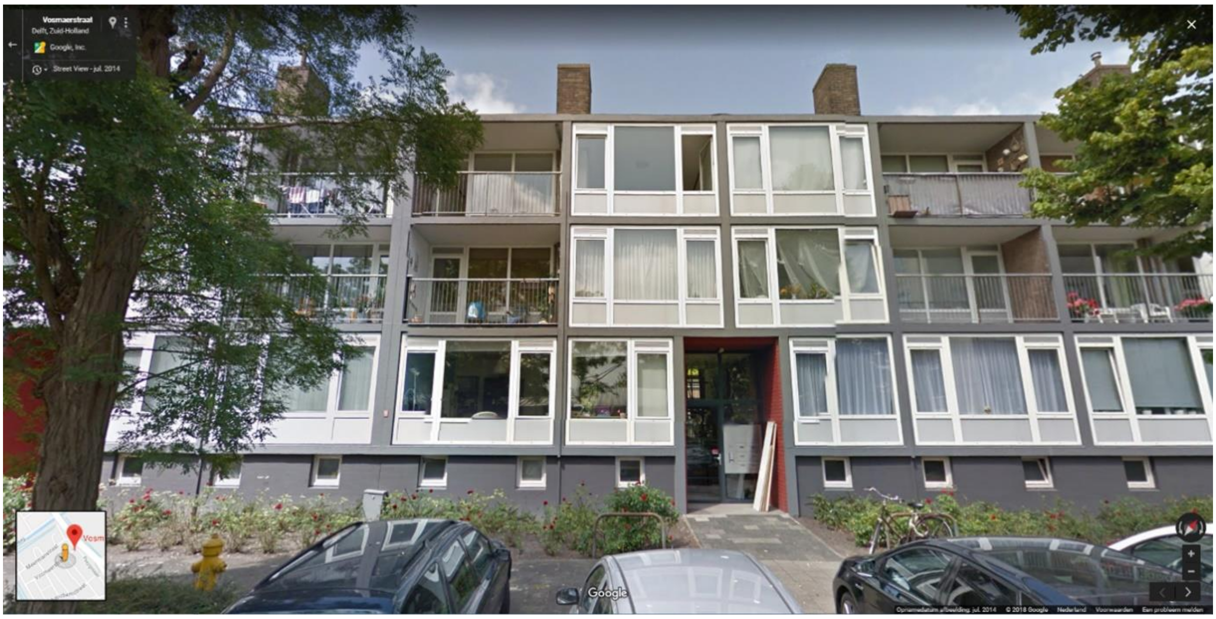


Figure 2. Front façade of the Delft demo site (Google maps streetview)

Figure 3. Back façade of the Delft demo site (Google maps streetview)

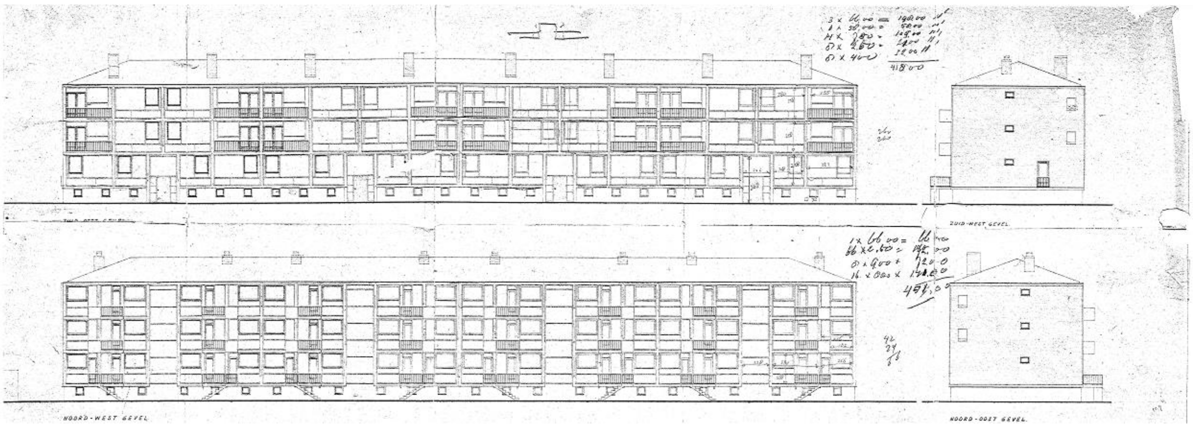


Figure 4. Section Delft demo site (Vestia)

Figure 5. Delft's demo site basic layout

3.1.1 Building characteristics

The construction of the building is a concrete skeleton, showing a visible grid on the façade, See Figure 6. This architectural element was common in the fifties and sixties, when there was little energy consumption awareness. It creates a direct thermal passage from the outside into the houses.
The building was renovated in the eighties. A major element of the renovation are the sandwich panels that fill the concrete grid. The panels have a R_c of 1,25 m^2K/W, which equals a poor insulation.

This building contains a large basement, this basement includes storage cabins for every apartment. Besides, a large space is empty near the stairwells in the basement, this empty space is owned by Vestia and nowadays used as area for gas pipes and gas heaters. From this place, shafts go upstairs to all the apartments. In addition, a shaft enters the building within the restrooms and mainly contain gas pipes.

Nowadays, a centralized heating system is used for hot tap water and space heating.

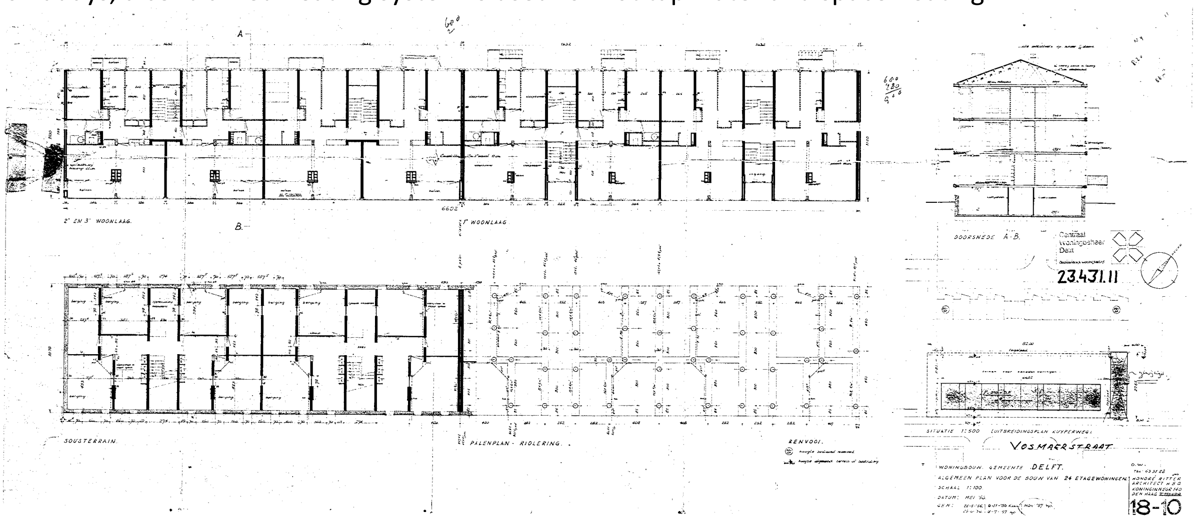


Figure 6. Floor map of the Delft demo site

Current situation	
+ Concrete basement	- Ornamental façade framework
+ General space in the basement	- Orientation
+ Slightly tilted roof	- Balconies
	- Hollow brick floor

Table 1. Overview advantages and disadvantages of the building for renovation

An element of general attention is the presence of asbestos in the building. From conversations with Vestia it was stated that there is possibly 10%. Where asbestos is located is not yet specified, since the team was not yet able to enter the apartments.

3.1.2 Building description

The first communication about Envision with the tenants only could take place as late as October 2018. This is why this little information from the tenants is available at the moment. Vestia is trying to obtain more information about the usage of gas and electricity during 2018 from the tenants. They recently received their energy bills of the past year.

Apart from that Vestia installed measuring equipment in two relevant apartments that collects data online of temperature, relative humidity, grades of CO_2 and ultra-fine particles. The figure below shows a picture of the equipment.

Four of these boxes, as small as a thick smartphone, are placed in the apartments, in the living room, the bedroom, the kitchen and the bathroom.

3.2 Weather Data Analysis

3.2.1 Outdoor air temperature

In Figure 18 the outdoor air temperature is plotted as measured by the Royal Netherlands Meteorological Institute (KNMI), the Dutch national weather service. We downloaded data of Rotterdam, the closest city to Delft. We have used the last 7.5 years of weather data to analyse the situation. In 2011 the temperature did not drop below -5 °C, and the highest temperature is around 32 °C.

Figure 18 also shows the radiation on a vertical surface. The vertical surface has a maximum radiation intensity of 800 W/m^2. One can also see that the highest radiation is in spring and autumn. Showing the potential for harvesting energy for that time of year.

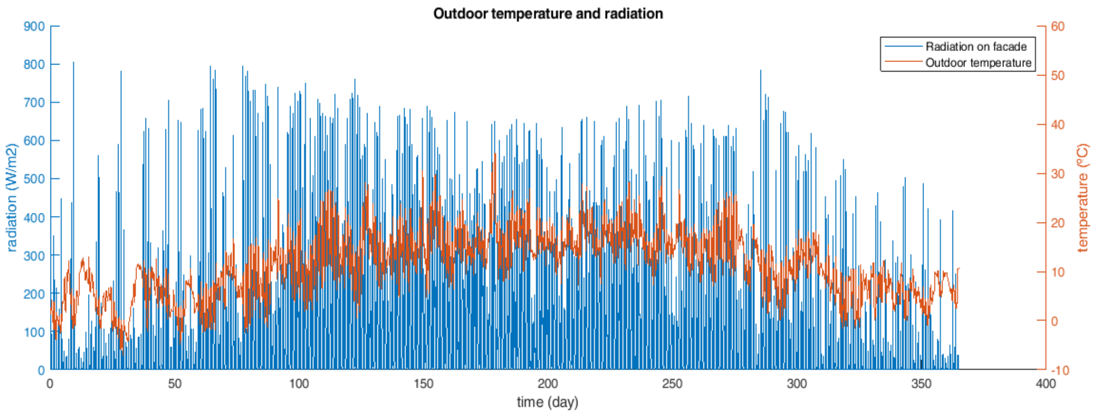


Figure 18: Outdoor temperature in Rotterdam (close to Delft Vosmaerstraat) (KNMI data 2011)

Figure 19 shows the amount of hours within 7.5 years that the outdoor temperature went below a certain temperature as given on the x-axis. One can clearly see that the amount of hours the temperature dropped below -7 °C, is less than 200 hours. Less than 26 hours (less than one day!).

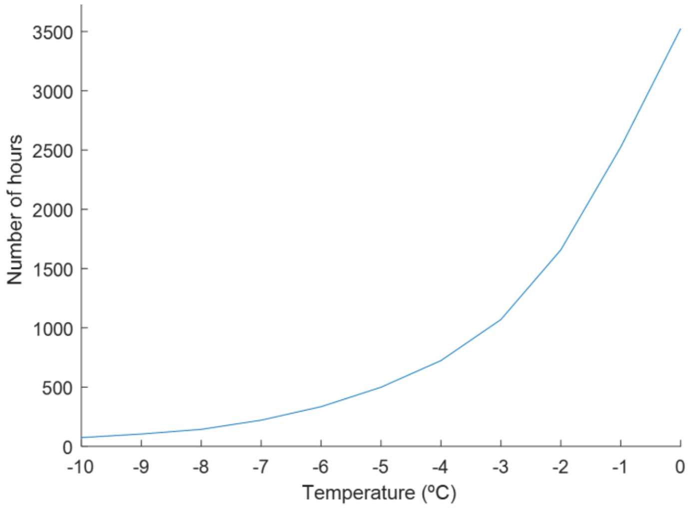


Figure 19: Number of hours below a certain exterior temperature in the last 7.5 years (KNMI data Rotterdam)

Let us investigate the worst case scenario. This is given in Figure 20. This figure shows that the temperature dropped down to -20 °C. This happens in case of a clear sky. Generally, this weather condition holds, resulting in a clear sky at day, meaning a high radiation from the sun. This leads to relatively high temperatures during the day, and the opportunity to harvest heat during day.

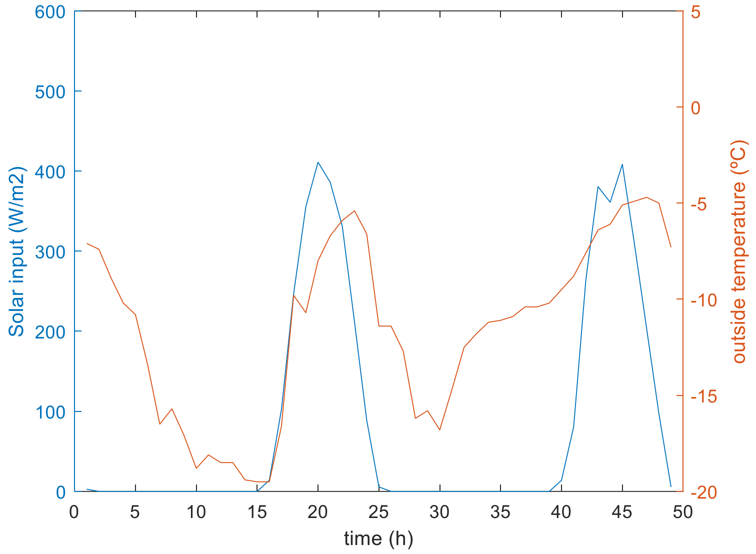


Figure 20: Worst case scenario in Rotterdam in last 7.5 years (KNMI data Rotterdam)

In case of buffering for one to two days one would be able to overcome below -7 °C situations. This is confirmed by Figure 21, that shows the amount of consecutive hours below a certain outdoor temperature. Below -6 °C for 24 consecutive hours, happened only 2 times during the last 7.5 years! With 2 days of buffering you will be able to manage this.

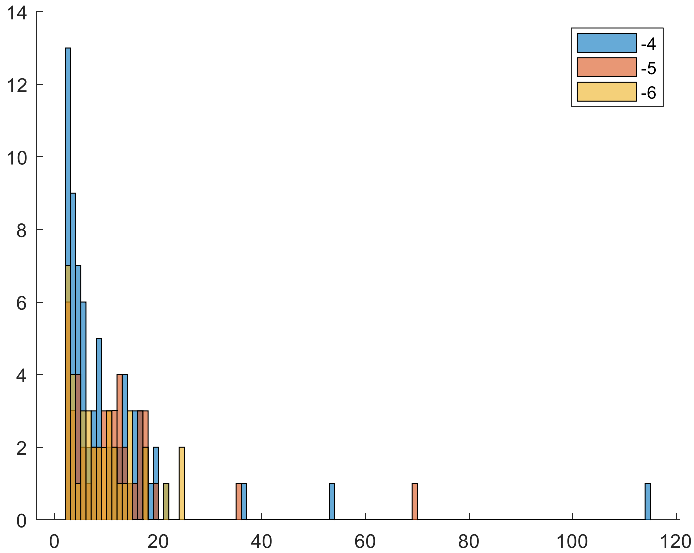


Figure 21: Amount of consecutive hours below a certain outdoor temperature in the last 7.5 years (KNMI data Rotterdam)

3.2.2 Humidity Ratio

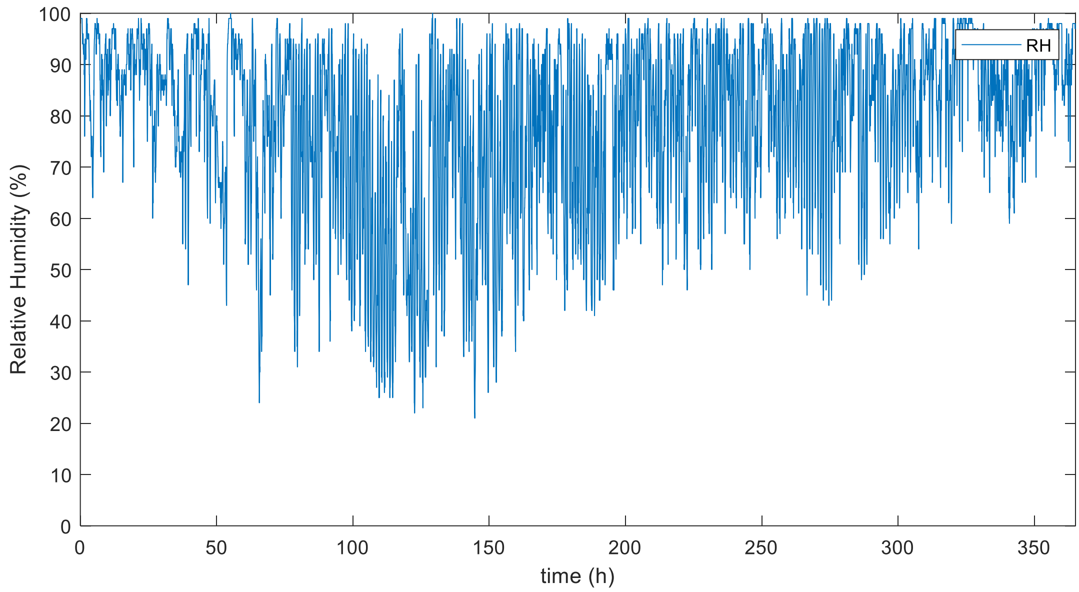


Figure 22: Relative humidity in Rotterdam (KNMI data 2011)

Figure 22 shows the relative humidity in Rotterdam. It is quite high, meaning that at low temperatures, freezing of the water against the panels would occur.

3.2.3 Solar radiation

To assess the amount of energy that can be harvested from the façade we have calculated the amount of energy each façade can harvest (considering a non-reflective surface). Detailed calculations are being generated by EDF, but are beyond the scope of this deliverable. On can see that the south façade may harvest about 2.5 GJ/m^2.

- "North" facade 1.3 GJ/m^2 (-50°) (actually: North-West)
- "East" end-facade 1.24 GJ/m^2 (40°) (actually: North-East)
- "South" facade 2.45 GJ/m^2 (130°) (actually: South-East)
- "West" end-side 2.53 GJ/m^2 (220°) (actually: South-West)

This is calculated in more detail in Figure 23, this figure shows the harvesting potential of a vertical façade (with a non-reflective surface surrounding the building). So the numbers are a bit underestimated. This shows that 2012 was the best year! Considering that the renovated buildings will only require about 12 GJ per apartment after a good insulation. This means a 288 GJ of solar energy is required. Taking that a south oriented façade may harvest 80% of the solar input, this would mean 2.5 GJ * 0.8 = 2 GJ/m^2. A surface area of 144 m^2 would be sufficient. This means 6 m^2 per apartment. Table 4 shows the amount of surface available for the Vosmaerstraat building. The first estimation shows that sufficient area is available.

Table 4: Surface available

Façade orientation	Surface available (m^2)
South	97
East	70
North	36
West	70
Total	273

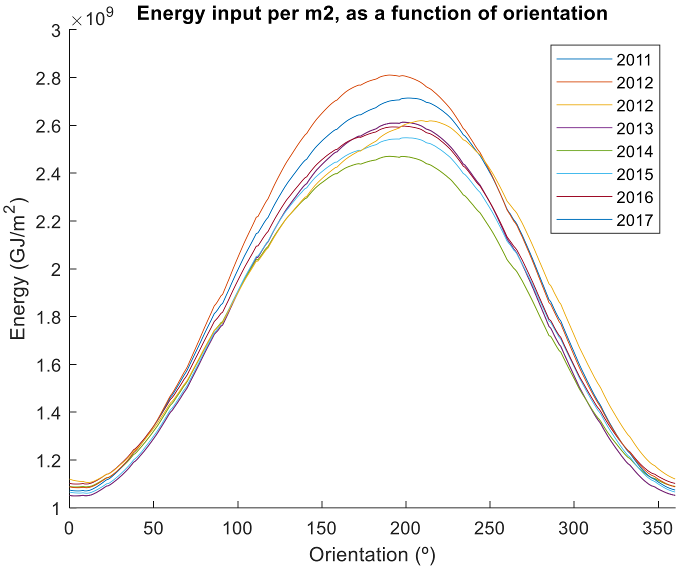


Figure 23: Total solar radiation for a vertical surface as a function of orientation (KNMI data)

3.2.4 Wind direction/intensity

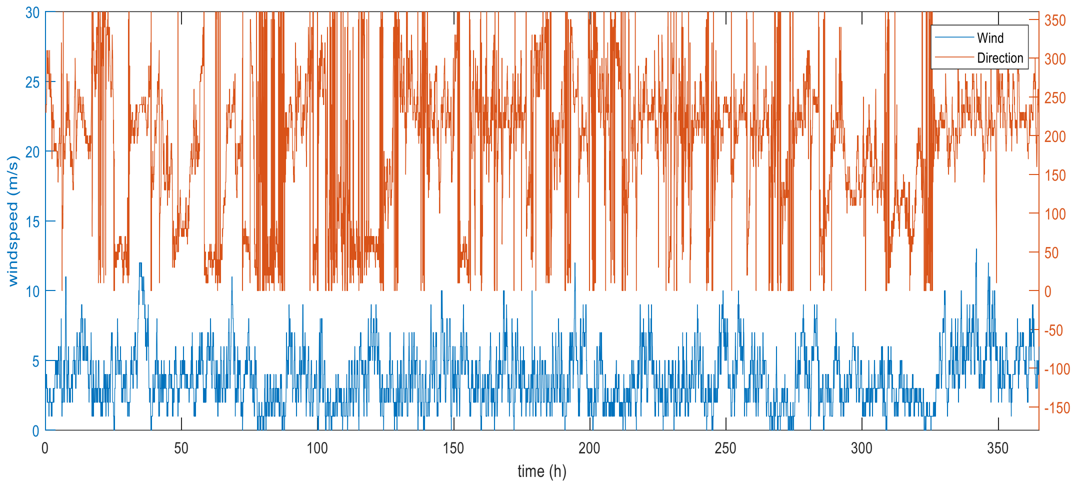


Figure 24: Windspeed and wind direction (KNMI data 2011) (360=north, 90=east, 180=south, 270=west)

Figure 24 shows the windspeed and wind-direction. The windspeed is quite equal over the year. The orientation of the wind mostly south-west.

3.3 Delft demonstrators baseline monitoring

The information required for a complete identification of the baseline buildings are summarized before:

- Geometric and thermo physical characteristics of the building
- HVAC system descriptions (mechanical, electrical and plumbing)
- Occupants behavior/habits (occupancy factor, indoor temperature set point, windows opening)
- Energy consumptions monitoring (e.g. through energy bills).

At the time of this deliverable issue, energy consumptions are not available in details. Additional detailed information will be included in the D5.3.

3.3.1 MEP system description

- All generating equipment is using natural gas for space heating and heating of tap water. The brands and types are varying. The oldest are AGPO, Domina F24 E, 25 kW, type Improved Performance, age over 15 years. AGPO, MegaDens 3, 21 kW, type High Performance, 9 to 10 years old. Remeha, Avanta 24C, 24 kW, type High Performance, 5 to 6 years old.
- The efficiency of the heaters is 85% for the Improved and 107% for the High Performance types.
- The type of the heat distribution system is an individual heater connected with radiators by non-insulated metal pipes.
- The circulation pumps, electrical capacity of 100 W, of the heating systems are built inside the heaters.
- The distribution of the heating systems is provided by radiators at a temperature of 70^{o} C incoming and 50^{o} C outgoing.
- Space temperature is regulated by a room thermostat placed in the living room.
- Gas and electricity meters are as a rule provided by the companies, that manage the networks.

electricity meter

gasmeter

3.3.2 Complete list of sensors/meters

The list of sensors and meters to monitor the system is already explained in D5.1, but will be mentioned again since it is described in D5.2 as well.

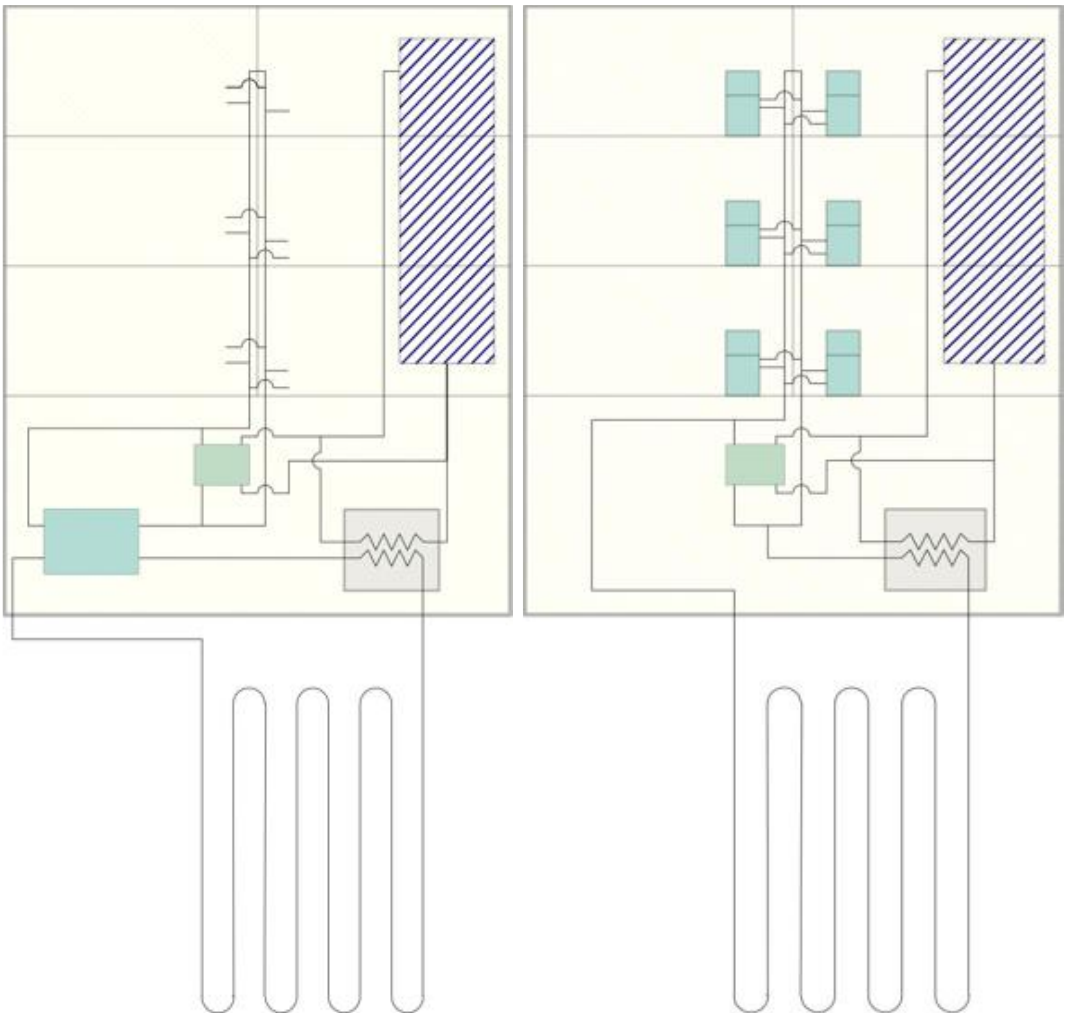
- Temperature (°C)
    - Temperature meters for water
        - Thermal collector
        - Storage tank
        - Ground Heat Exchanger
        - DHW
        - Space Heating
    - Temperature meters for air
        - Indoor (next to the thermostat)
        - Outdoor
        - Ventilation
    - Surface temperature (PV glass) , maybe just staircase temperature
- Flow meters (m^3 /h)
    - Water
    - Air
- Energy meters? (GJ) (or is it calculated after just with flow , T and Cp)
    - Space heating delivered
    - Solar panel produced
    - Heat exchanged in the ground
    - Heat loss in the storage (?)

- Electric meters (kWh)
    - PV panels in the roof
    - PV glass in staircase
    - HP consumption
    - Water pump consumption
    - Mechanical ventilation consumption
    - Household device consumption
- Outdoor weather station
    - Irradiance (w/m2)
    - Temperature
    - Wind Speed (m/s)
    - Relative humidity (%)
- Indoor air quality
    - CO2 level (ppmv/m^3)
- Other
    - HP mode
    - Water consumption amount (l)

Monitoring framework (real time) Vosmaerstraat

During the exploratory visits last October, the tenants were asked to share their energy consumption data (gas, electricity) with Vestia. A number of tenants was cooperative. The figures were supplied recently. The use of gas will be divided in heating and cooking. The use of gas for cooking is out of or scope. The use of gas for heating will following standard procedures be divided in space heating and tap water heating for washing and showering.

The energy usage in the new situation, after renovation, will be measured no matter what. This is indifferent of the type of energy supply. Vestia is considering the use of water/water heatpumps. The choice for individual or collective heatpumps or an intermediate solution is in the making, but not definitive.



Nevertheless, we are considering to measure the following parts in the new situation:

Customer level (level 1)

The customer pays a certain amount of money to Vestia for the use of the energy facility.

In case of a collective system the customer, apart from the fixed prize, pays an amount for the energy consumption. Tariffs are determined beforehand by Vestia Energie. The basis for the tariffs is the average consumption, depending on the size of the connection and the average performance.

Of course the comfort, which is provided, is of importance. Especially the quality of heating (and cooling) and hot tap water is dominant.

Energy

- Consumed thermal energy space heating. Per client 2*TT (thermal transmitter) 1*FT (flow transmitter).
- Consumed thermal energy cooling (optional). Per client 2*TT 1*FT. However, if heating and cooling are deployed using the same network, 1 FT sensor is enough to register the energy consumption, be it in two separate registers.
- Consumed thermal energy hot tap water. Depending on the situation, individual or collective. Per client 2*TT 1*FT, worst case.

Comfort

- Actual space temperature vs. setpoint main thermostat. 1*TT. This TT is built in the main thermostat.
- The regulation of the heat curve requires measuring of the incoming temperature of the central heating and of the outside temperature. Per client 2*TT. With individual systems the first TT is cancelled, because it is part of the first bullet under energy.
- The same with the regulation of the heat curve when cooling. One outside temperature TT suffices per client. Perhaps more clients can be coupled on 1 TT
- Actual temperature high in the hot water vessel (individual provision). 1*TT.
- Actual temperature low in the hot water vessel (individual provision). 1*TT.
- Incoming temperature HT (high temperature) pipe (collective provision hot water). 1*TT.
- Outgoing temperature HT pipe (collective provision hot water). 1*TT.

The result of level 1 is:

The customer takes delivery of energy. The price he pays for this is justified.

The customer has sufficient comfort. The system meets the demands and wishes of the customer.

Level 2 (system return)

To test the prices used by Vestia Energie, it is necessary to determine the return of the system. This is important to determine the financial return of the exploitation and can be a tool to adjust the prices used.

Beside the consumption of the customer, of which the methods of measuring are written above, the measuring on source level and at the generating installation is necessary.

Level 2.1 (sources)

The way it looks at the moment we will have two types of sources at the Vosmaerstraat.

The first source is Envision façade Panels, the second closed loops underground aka vertical ground heat exchangers.

Envision Panels

The output of the panels will be measured per cluster. Meaning, if 3 apartments are connected to 1 energy supply, the output of all panels attached will be measured together. The necessary equipment is 2*TT 1*FT.

Using a totalizer the total of all energy output will be registered.

Optional

If the panels are used for cooling the necessary equipment consists of 2*TT extra. No FT is required, because it is already installed for the heating mode.

Using a totalizer the total of all energy output will be registered.

Closed ground loops

The extracted thermal energy will be measured per closed loop system.

In heat supply mode of the energy system heat is being delivered to the apartments and cold to the ground loops. 2*TT 1*FT.

Using a totalizer the total of all energy output will be registered.

Optional

In cold supply mode of the energy system, the other way around, cold is being delivered to the apartments and heat to the ground loops. 2*TT. No FT is required, because it is already installed for the heating mode.

Using a totalizer the total of all energy output will be registered.

It is of the utmost importance, that the temperature of the medium of the closed groundloops is monitored properly, in order warn in case of possible exhaustion.

Level 2.2 (generating installation)

For the generating installation Vestia is considering the application of water-water heatpumps.

At the moment it is not decided, if it will be individual or collective systems. The brand of the heatpumps is not sure either.

Water-water heatpumps

Apart from the measurement transmitters to be installed within the framework of Envision, most of the in the Netherlands available brands of heatpumps are equipped with very extensive on board monitoring.

This measures among others the following relevant parameters:

- Incoming temperature of the source at the evaporator.
- Outgoing temperature of the source at the evaporator.
- Incoming (CH) temperature and flow at the condensor.
- Outgoing (CH) temperature at the condensor.
- Pressure at the evaporator.
- Pressure at the condensor.
- With an internal hot water vessel installed the temperature at the top.
- With an internal hot water vessel installed the temperature at the bottom.
- Recently the standard on board monitoring is extende with kWh measuring.

With the relevant measuring above the coefficient of performance (COP) and the seasonal performance factor (SPF) can be deduced.

Because the water water heatpump is the centerpoint of the energy supply, where all flows come together, distribution and transport losses of energy can be determined.

The result of level 2 is:

The sources provide enough power and energy to meet the customer's demand.

The energetic performance is good and through that enough environmental savings are realized.

The energetic performance is good and through that a profitable exploitation is feasible.

Level 3 (components)

Components are experiencing wear and tear or even failure. In both cases this must be anticipated by measuring. From measuring also can be learned the results don't meet the expectations. To make adjustments in these cases additional measuring is necessary.

Delivery customer

- CH pressure home installation. 1*PT (pressure transmitter).
- Flow speed from the hot water vessel needs to be restricted following the specifications of the manufacturer to prevent thermal mixture in the vessel.
- Degassing and venting of the delivery system to prevent corrosion.
- Application of a magnetic filter in the home installation as an option.

Envision Panels

- Measuring of glycol against the danger of freezing. Before winter yearly??
- Temperature of the surface of the panels.
- Radiation temperature??
- Extent of cooling through wind??
- Flow speed / pump settings / pump pressure??
- Detection of leakage per loop. 1*PT
-

Closed groundloops

- During the installation the loops will be tested on consistency against leakage.
- Measuring of pressure while operating to detect possible leaks. 1*PT.
- If it is mandatory to operate with low temperatures a water/ glycol filling can be necessary. In that case measuring the rate of glycol is necessary. Yearly before winter??
- Degassing and venting of the filling is a necessity as well.
- During a prolonged standstill (mainly usage of the panels as the source) bacteriological contamination may occur (bio film).

Generating installation

- All necessary measurings are on board.
- Malfunctions will be sent by monitoring on board to the server and/or the maintenance company!

The result of level 3 is:

Disappointing performances will be made visible and can be adjusted by changing setting and/or substituting components.

Malfunctions are detected real-time by monitoring from a distance and can be solved quickly.

The customer receives adequate and timely support.

3.3.3 Occupants behaviour

Values of year 2011 show a large variety (label G to C) between the labels of the apartments. Label G is the lowest label a house can get. This means that a lot of energy will be lost, and therefore a lot of money will be wasted. Label C is a more sustainable label, however, still some energy will be lost. With some additions to the building, the label will go easily to B, A or energy neutral. For more specific information, tenants have to collect their energy usage and gas usage and send it to Vestia. Tenants are asked to do this, however, there is little result.

Household	Yearly usage		Thermostate	
	electricity	natural gas	degrees celsius	degrees celsius
Number of persons	**kWh**	**m³**	**daytime**	**night time**
2	1415	2374	20	17
1	1352	997		
5	2935	1513	26	20,5
1			19	12
2	207	1665	22	16
1	1678	1774	23	16
1			20	20
2			21	?
2			20	20
1			21	16
4	3194	1136		
1	1616	1656	21	
Input energy usage by tenants				

Table 5. energy usage data collected from tenants

Now that the tenants are better informed about the Envision project another attempt will be done to get data of 2018 as complete as possible.

The company that manages the gas and electricity networks, Stedin provided a limited data sheet on energy usage over 2018, shown below.

ENERGY usage 2018

Vosmaerstraat Building 1	Gas Usage	Electricity Usage
woning 1	1650	1700
woning 2		
woning 3		
woning 4	1000	2000
woning 5		
woning 6		
woning 7	1050	1800
woning 8		

Vosmaerstraat Building 2	Gas Usage	Electricity Usage
woning 1	600	1900
woning 2		
woning 3		
woning 4	1200	1700
woning 5		
woning 6		
woning 7	700	1500
woning 8		

Table 6: Energy consumption 2018 data provided by Stedin

Just the same year, Vestia made an estimated calculation of the consumption of energy before and after renovation.

Construction year	before renovation	after renovation	unit
Construction year Living area	1955 77	2020 77	[-] [m2]
Space heating	65 5.005 18,02	25 1.925 6,93	[kWh/m2] [kWh] [GJ]
Domestic hot water	21 1.648 5,93	21 1.648 5,93	[kWh/m2] [kWh] [GJ]
Auxiliary energy heating	8,0 616	8,0 616	[MJ/m2] [MJ]
Cooling	- -	12,00 924	[MJ/m2] [MJ]
Ventilation	- -	4,95 381	[MJ/m2] [MJ]
Household equipment	26 2.002	26 2.002	[kWh/m2] [kWh]
Gas-fired Gas boiler efficiency - space heating Efficiency gas boiler - hot tap water Efficiency heat pump - space heating Efficiency heat pump - hot tap water	1 0,95 0,55 5,00 3,00	- 0,95 0,55 5,00 3,00	[yes=1; no=0] [-] [-] [-] [-]
Energy usage			
Space heating Auxiliary energy space heating Domestic hot water Cooling Fans	599 - 67 341 - - -	- 385 67 - 549 100 41	[m3] [kWh] [kWh] [m3] [kWh] [kWh] [kWh]
Subtotal building Domestic	940 67 2.002	- 1.142 2.002	[m3] [kWh] [kWh]
Total gas consumption **Total electricity consumption**	**940** **2.069**	**-** **3.144**	**[m3]** **[kWh]**

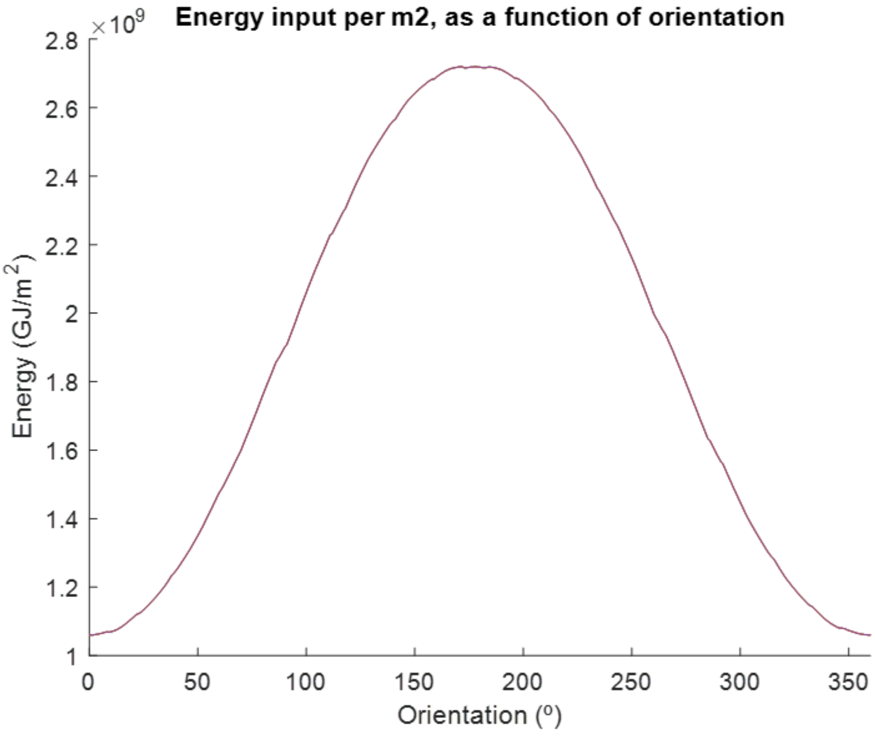


Figure 7. Energy input per m2, as a function of orientation

Since the information of energy and gas usage of the tenants of the Delft demo site are not yet available, references are used. These references are shown in Table X. These numbers are checked with other projects that BAM has realized and seem to be reliable. Therefore, those numbers will be used for further calculations but will be replaced when more information is available of the tenants of the Vestia building (Aedes, 2018).

The current energy labels within the building differ from C,D,E, F and G.

3.4 KPIs

With reference to the APPENDIX C of the D5.1 "KPIs plan for monitoring and assessment of the technologies at demo site levels", only the Baseline (B) KPIs will be calculated. In order to provide a complete overview all the KPIs are following reported:

Name of demonstrator	KPI type	Progressive number	Design stage
De	Env	1	**B**
De	Env	2	**B**

De	Env	2	P
De	Env	3	**B**
De	Env	4	**B**
De	Env	5	**B**
De	Env	6	**B**
De	Env	6	P
De	Eco	1	P
De	Eco	2	P
De	Eco	3	P
De	Eco	4	P
De	Eco	5	P
De	Eco	6	P
De	Eco	7	P
De	Soc	1	**B**
De	Soc	1	P
De	Soc	2	**B**
De	Soc	2	P
De	Soc	3	**B**
De	Soc	3	P
De	Thr	1	P
De	Thr	2	P
De	Thr	3	P
De	Elc	1	**B**
De	Elc	1	P
De	Elc	2	**B**
De	Elc	2	P
De	Elc	3	**B**
De	Elc	3	P

Table 7 Delft's Demonstrator Generic KPIs – List

Specific KPIs, in particular, will be taken into account in the Post Renovation stage (P).

Name of demonstrator	KPI type	Progressive number	Design stage
De	COP/EER	1	P
De	Solar_Eff	1	P
De	Storage_Losses	1	P
De	DH heating_cycles	1	P
De	PV_Eff	1	P

Table 5 Delft's Demonstrator Specific KPIs – List

Due the lack of actual performance data, the KPIs (both Baseline and Post Renovation) will be calculated and included in the deliverable 5.3.

4 Pilkington Demonstrator

4.1 Building Information

For the Envision - Horizon 2020 Project, we really wanted to contribute by implementing our Pilkington Pilkington **Sunplus™ BIPV** Technology into a Pilkington Building. As Pilkington Nederland BV works closely together with another Pilkington downstream plant in Austria, we suggested to renovate their façade with Pilkington Pilkington **Sunplus™.** This suggestion has been approved by the NSG Pilkington European Management.

Description of the Demonstration

- Location:
- Pilkington Austria GmbH
- Bundesstraße 24,
- 5500 Bischofshofen, Austria
- https://www.google.nl/maps/place/Pilkington+Austria+GmbH/@47.3983628,13.2161245,400m/data=!3m1!1e3!4m5!3m4!1s0x0:0xa3a61755e74f6d5d!8m2!3d47.3990418!4d13.2171867

What is going to be done?

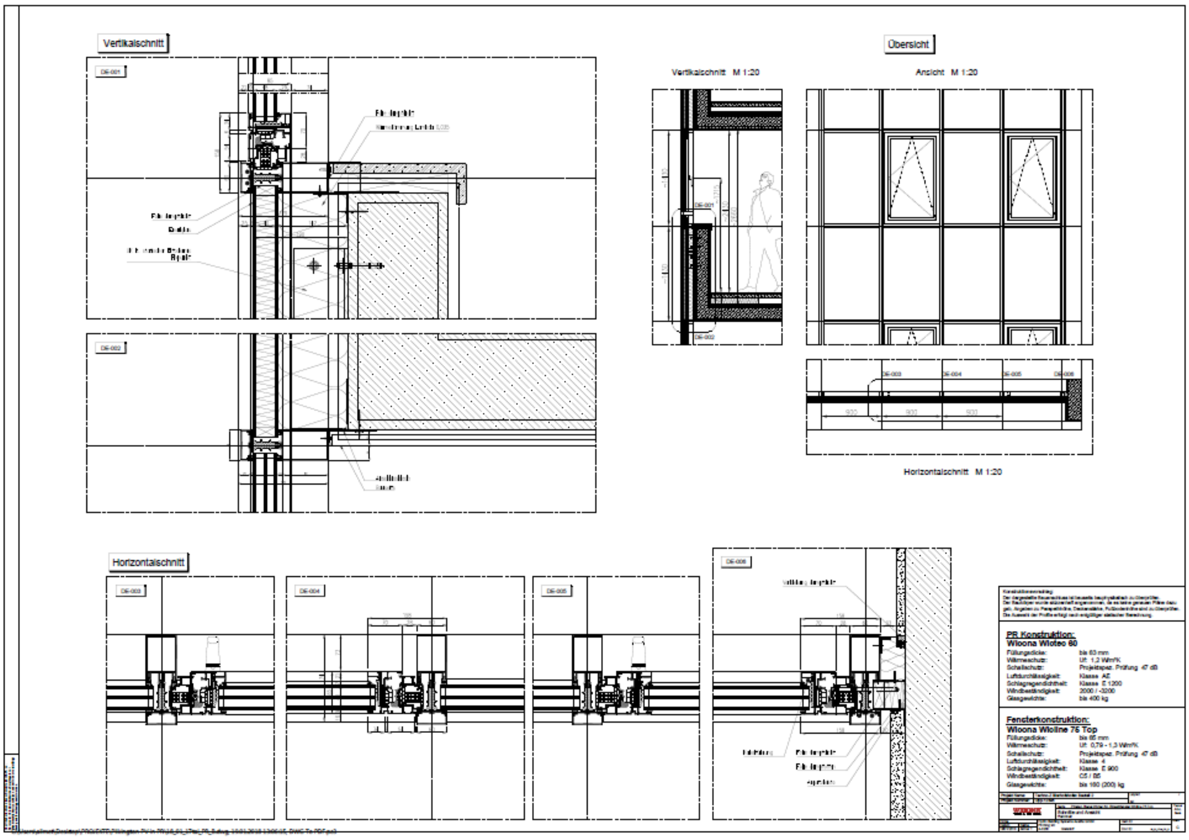
Front Façade Office Pilkington Austria to be renovated

Geographic situation Façade: abt. 171° south-east

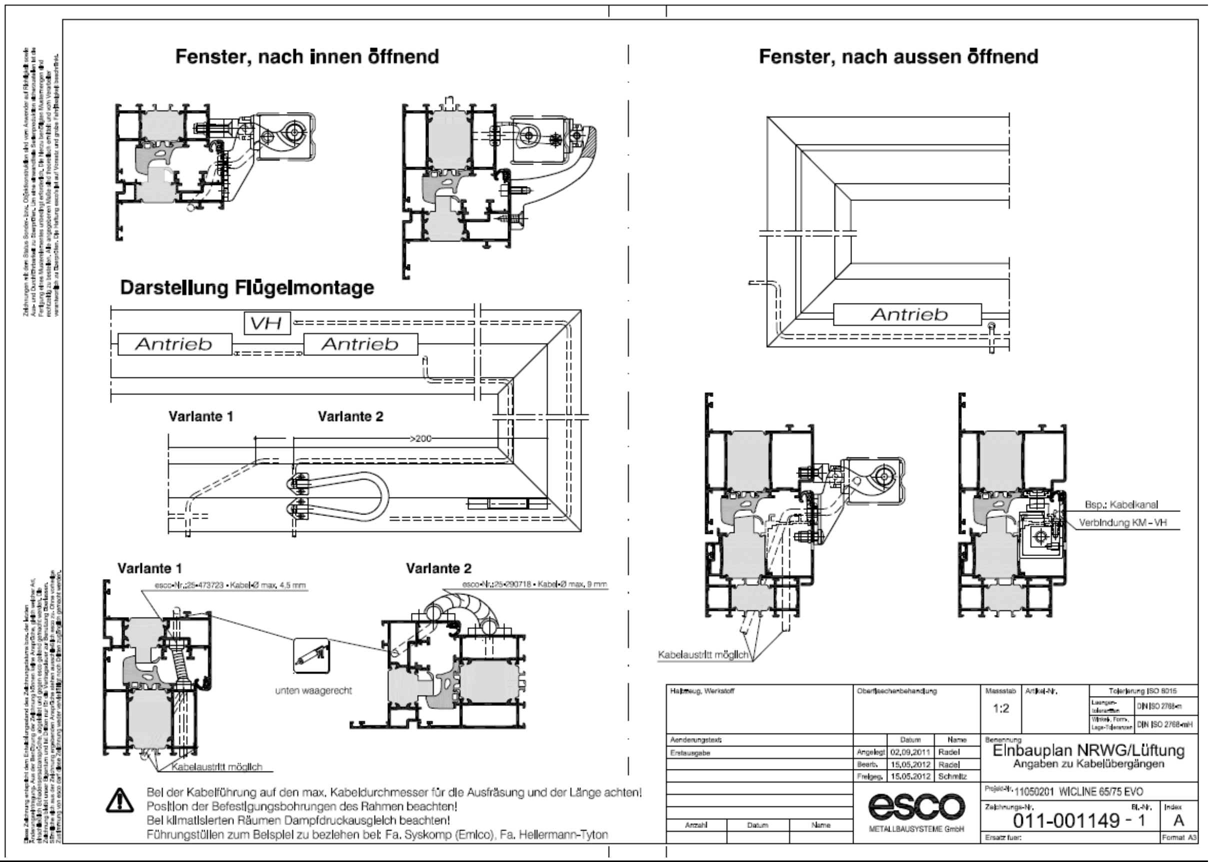
<u>Supplier Frames:</u>

Wicona GmbH - Pirching 90, A-8200 Gleisdorf

Model Wictec 60



Vertikalschnitt
Übersicht
Vertikalschnitt M 1:20
Ansicht M 1:20
Horizontalschnitt M 1:20
Horizontalschnitt
PR Konstruktion:
Wicona Wictec 60
Füllungsdicke: bis 63 mm
Wärmeschutz: Uf: 1,2 W/m²K
Schallschutz: Projektspez. Prüfung 47 dB
Luftdurchlässigkeit: Klasse AE
Schlagregendichtheit: Klasse E 1200
Windbeständigkeit: 2000 / -3200
Glasgewichte: bis 400 kg
Fensterkonstruktion:
Wicona Wicline 75 Top
Füllungsdicke: bis 65 mm
Wärmeschutz: Uf: 0,79 - 1,3 W/m²K
Schallschutz: Projektspez. Prüfung 47 dB
Luftdurchlässigkeit: Klasse 4
Schlagregendichtheit: Klasse E 900
Windbeständigkeit: C5 / B5
Glasgewichte: bis 180 (200) kg



Installer / Installation Company Solar:

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

Project meeting with partners 21-11-2018 at Bisschofshofen

Pilkington Germany-Austria-Netherlands

TNO / SEAC Eindhoven

Wicona

Electrotechnik Kontriner

What is the argumentation?

- Winter: Problems poor Isolation, High heatings costs
- Summer: Problems too much heat inside the building
- Current Glass: 4-16-4 U Value 1,5 W/m.2 - Installed 1992
- NSG “Showroom Façade” for Architects, customers and other market partners
- Experience center to learn more about our Pilkington **Sunplus™** BIPV
- Central point in Europe, in The Netherlands we also have the Solarbeat / SEAC / GTB Lab. We think a central European location in Austria could fit in the Envision vision.

What are the technologies that going to be demonstrated?

- ➢ Total 27 Pcs. Pilkington Triple Sunplus™ 51% Coverage – abt. 32 m²

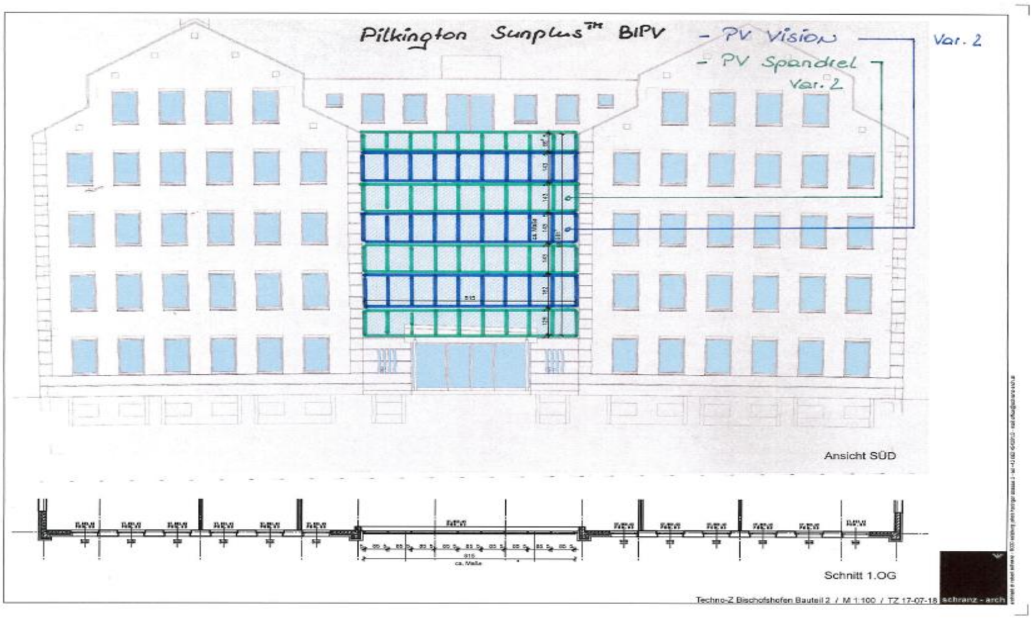
  Pilkington Sunplus BIPV Vision in 9,5 mm - 12 mm SZR - Pilkington Low E Pro-T S3 - 6 mm - 12 mm SZR - Pilkington Optitherm S3 6 mm – to be manufactured by Pilkington Enschede

- Amount of m²:
  - 9 pcs 800 x 1600 mm (WxH)
  - 18 pcs 800 x 1420 mm (WxH)

- ➢ Total 36 pcs. Spandrels - abt. 36 m².

  Spandrel full black monocrystalline - Solar Strings width abt. 10 mm

- Amount of m²
  - 9 pcs 800 x 1260 mm (WxH)
  - 18 pcs 800 x 1430 mm (WxH)
  - 9 pcs 800 x 860 mm (WxH)



Expected installation?

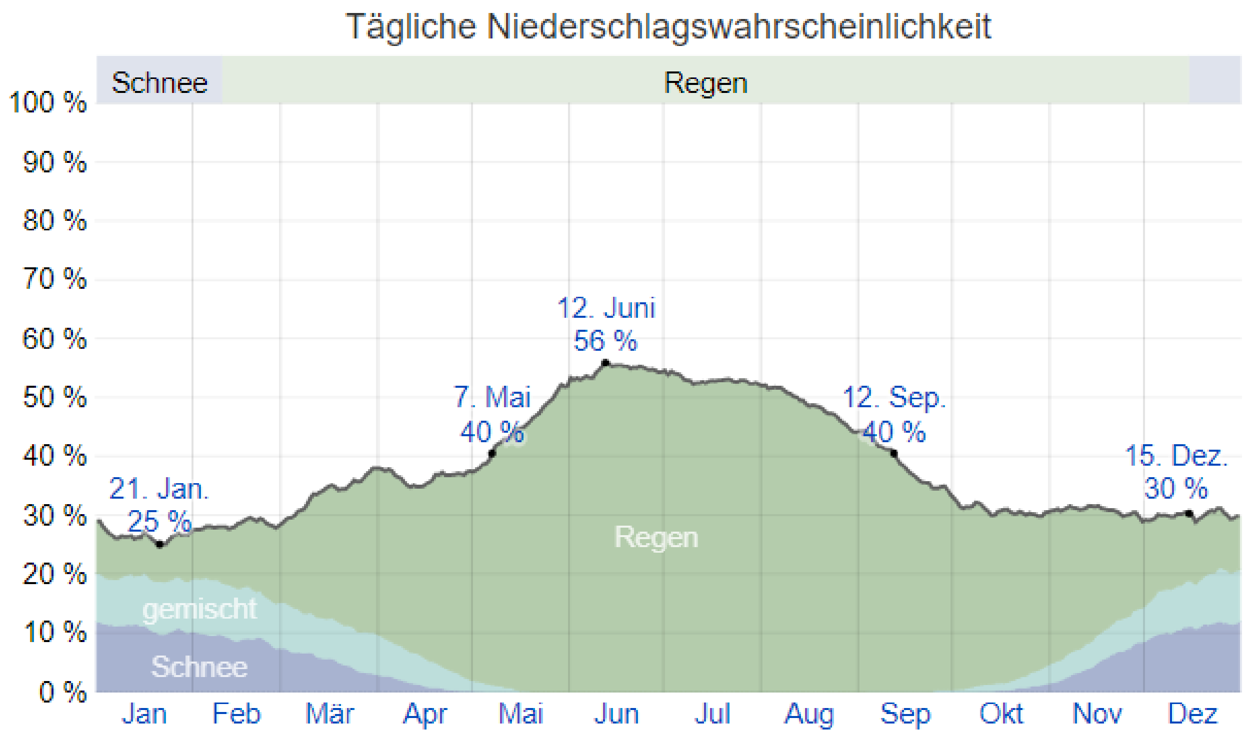
Mid 2019

4.2 Weather Data Analysis

4.2.1 Outdoor air temperature

The above graphs show the average temperatures and hours of daylight throughout a year.

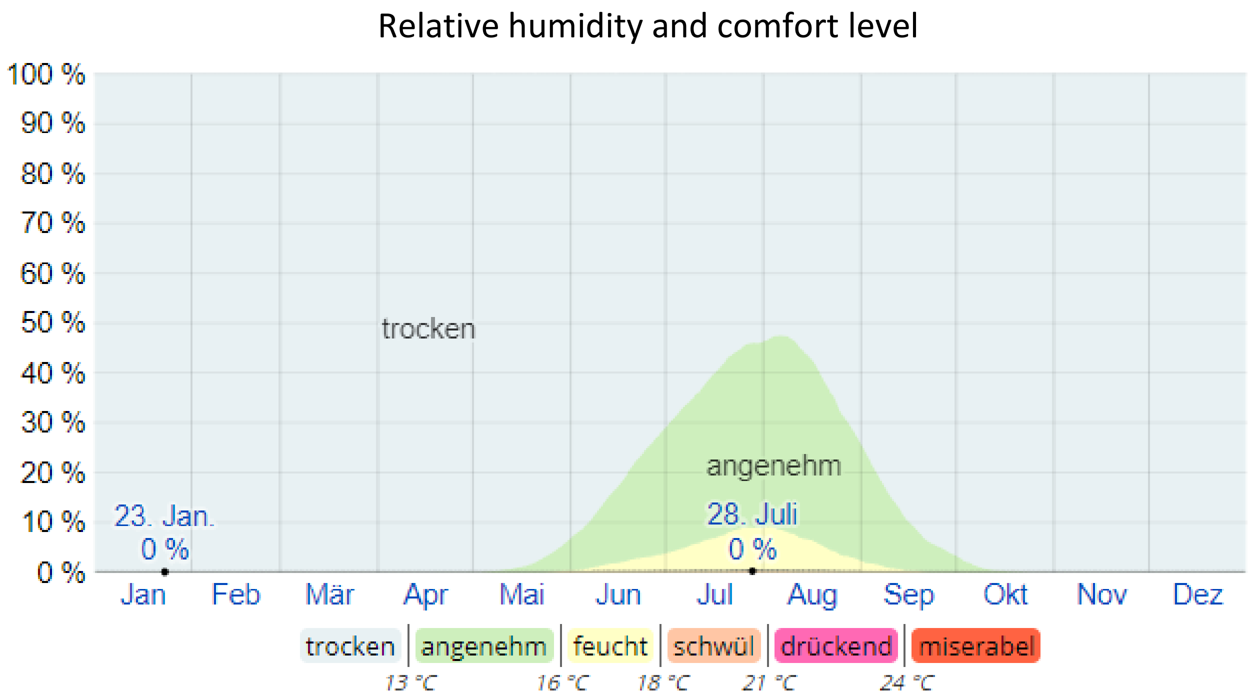
4.2.2 Humidity Ratio



The graph shows the different types of precipitation that where observed in percentage (Rain, snow, or mixed)

The above graphic indicates the average probability of precipitation throughout the year. It confirms the idea of tourists that you're in for a rainy holiday if you plan your summer vacation in Austria.

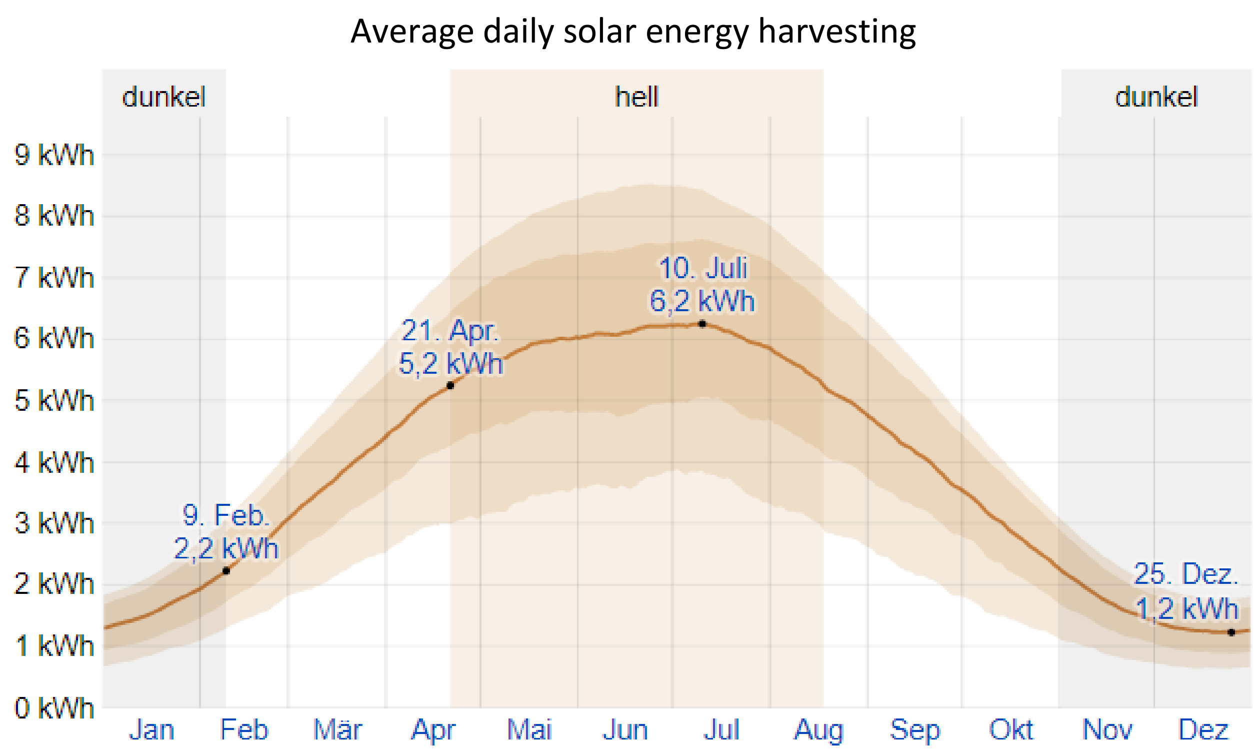
In addition the graph below on humidity and comfort level.



The part of the relative humidity and comfort conditions in percentage, using dewpoint categories.

The above graphic shows the relative humidity, measured in relation to the dewing point. The comfort levels concerned vary from dry (grey) to pleasant (green) and humid (yellow).

4.2.3 Solar radiation

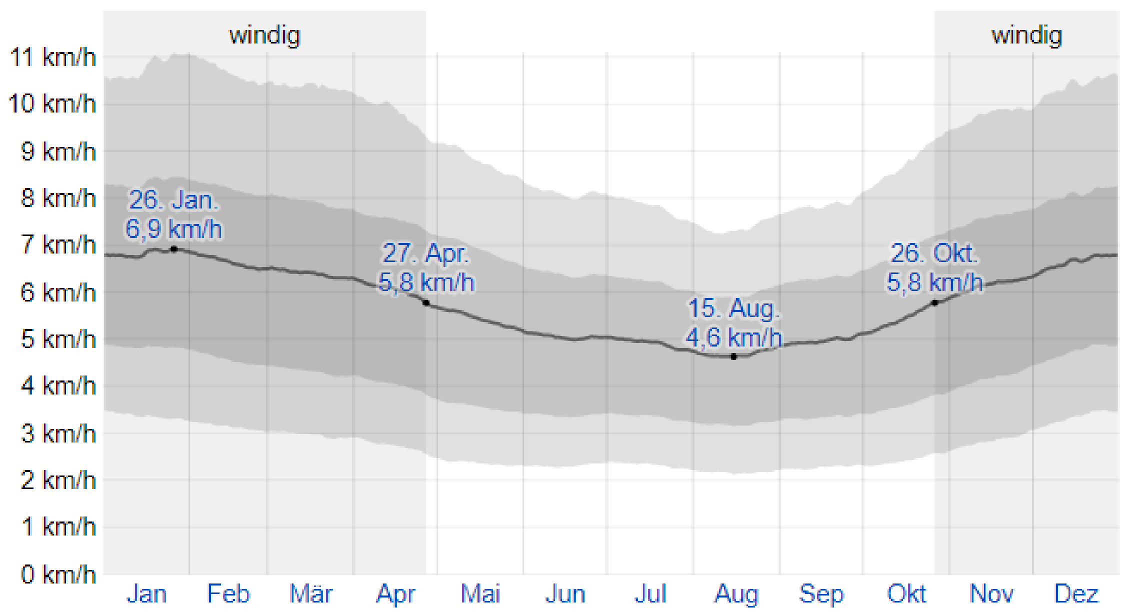


The daily production of solar energy, at the earth surface per square meter, with percentage bands of 25 to 75%, and 10 to 90%.

The above graphic shows the average daily amount of solar energy at ground level per square meter. This is represented by the orange line. The deviation between 25% and 75% is shown in the darker area around the orange line, the deviation between 10% and 90% in the lighter area.

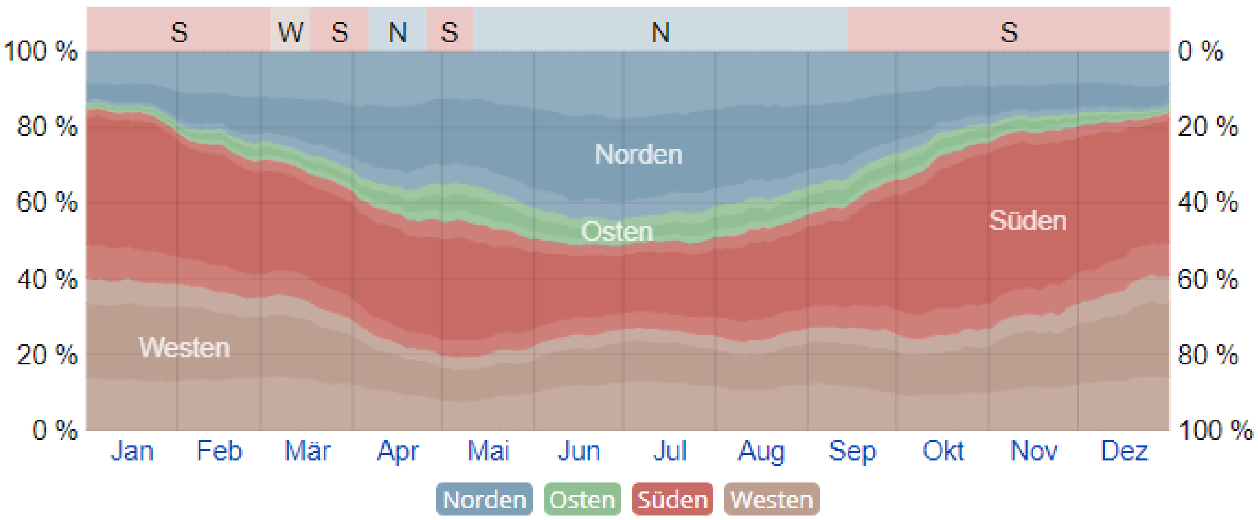
Wind direction/intensity

Average windspeeds



The above graphic shows the average windspeed in kilometres per hour. This is represented by the grey line. The deviation between 25% and 75% is shown in the darker area around the grey line, the deviation between 10% and 90% in the lighter area.

Wind-direction



The above graphic shows the average wind direction measured over the hours with exception of the hours, that the wind speed is below 1.6 kilometers per hour. It is remarkable, that the wind hardly ever comes from the East.

4.3 Pilkington baseline monitoring

4.3.1 Current energy usage

Raumaufteilung Pilkington Austria

Büros Pilkington Nummerierung	Büros lt. Mietvertrag	Stromzähler
Büro 1 - Personalabteilung	E04a	
Büro 2 - Versandabteilung	E04b	
Büro 3 - Vertriebsabteilung	E15 - E18, E20 - E22	
Büro 4 - Planungsabteilung	E19	
Büro 5 - Einkauf und Controlling	203 *	Büro 203, 204 und 209
Büro 6 - Hubert Schwarz (GF)	204	Büro 203, 204 und 209
Sozialraum	E06	
Schulungsraum 1. OG	102 **	
Besprechungsraum 2. OG	209	Büro 203, 204 und 209
Büro Qualitätsabteilung	106	Büro 106
Büro Lohnverrechnung	115, 116	Büro 115 und 116

Fassadenerneuerung betrifft:
Schulungsraum
Einkaufsbüro

* Stromabrechnung für Büro 203, 204 und 209
** Keine Stromabrechnung vorhanden

Stromverrechnung Salzburg AG

Abrechnungszeitraum	Büro 106			Büro 115 und 116			Büro 203, 204 und 209			Summe	Summe
	kWh	€ (netto)	€ / kWh	kWh	€ (netto)	€ / kWh	kWh	€ (netto)	€ / kWh	kWh / Jahr	€ (netto) / Jahr
21.05.2015 - 20.05.2016	19.112,00	€ 2.706,10	€ 0,14	2.661,00	€ 475,68	€ 0,18				21.773,00	€ 3.181,78
21.03.2016 - 20.05.2016							1.688,00	€ 252,70	€ 0,15		
21.05.2016 - 18.05.2017	25.007,00	€ 3.431,75	€ 0,14	2.023,00	€ 387,24	€ 0,19	3.749,00	€ 619,22	€ 0,17	30.779,00	€ 4.438,21
19.05.2017 - 18.05.2018	23.061,00	€ 2.739,43	€ 0,12	2.717,00	€ 423,59	€ 0,16	3.250,00	€ 484,94	€ 0,15	29.028,00	€ 3.647,96
Durchschnitt	22.393,33	€ 2.959,09	€ 0,13	2.467,00	€ 428,84	€ 0,18	3.499,50	€ 552,08	€ 0,16	27.193,33	€ 3.755,98
Summe	67.180,00	€ 8.877,28		7.401,00	€ 1.286,51		8.687,00	€ 1.356,86		81.580,00	€ 11.267,95

Erdgasabrechnung							
Gesamtnutzfläche Bürogebäude:		1.428,41	m2				
Nutzfläche Schulungsraum 1. OG:		60,96	m2				
Nutzfläche Büro 5 (EK & Cont.):		47,73	m2				
Abrechnungszeitraum	**Gesamt**					**Schulungsraum 1. OG**	**Büro 5 - EK & Cont.**
	Erdgas	**kWh**	**kWh / m2 NFL**	**€ (netto)**	**€ (netto) / m2 NFL / Jahr**	**kWh (umgelegt)**	**kWh (umgelegt)**
2015		193.595,00	135,53			8.262,02	6.468,93
2016		196.334,00	137,45			8.378,91	6.560,46
2017	21.208,52	224.828,00	157,40	10.520,28	7,37	9.594,94	7.512,58

4.3.2 Complete list of sensors/meters

Because the parameter Performance Ratio (PR) is a defined as the division between actual energy yield and irradiance on the so-called Plane-Of-Array (POA), both parts of that division need to be measured. This chapter will contain all the monitoring information (results) of pre-monitoring actions.

4.3.2.1 Measurement Planning

For outdoor PV-system analysis a one full year analysis is highly recommended. The reason is that every period of the year will have its specific climatic conditions that have an influence on the performance. Of most importance, of course, is the irradiance. Moreover, the experience with PV-facades in the international PV-community is much more limited than with PV-roofs (flat or pitched). But not only irradiance is important, also ambient temperature and wind speed will influence performance.

Therefore, from the first day of installation onwards, the performance will be monitored. TNO-SEAC recommends to extract each month a performance report. This can largely automated with software. But the analysis of that month-report is up to the experts. TNO-SEAC can compose the monthly report (provided that the internet connection is stable and measurement data comes in flawless) and send that report e.g. by e-mail to Pilkington-NSG. That report will also include some typical observations of that month. In case of installation problems, they will become clear soon (worst-case within 30 days), and mitigation action can be arranged from Pilkington-NSG.

4.3.2.2 Electrical Measurement Equipment

As mentioned, the DC measurement of electrical power and yield would normally beyond the scope of WP5.1 (too much monitoring). It is described in the experimental setup of WP3.1.

For the AC measurement we like to rely on the monitoring software of the inverter of choice. At the moment of writing this inverter has not been chosen yet. As example, we show a screenshot of the monitoring of another project at SEAC-SolarBEAT that makes use of SolarEdge. This is just an example brand! See Figure 25.

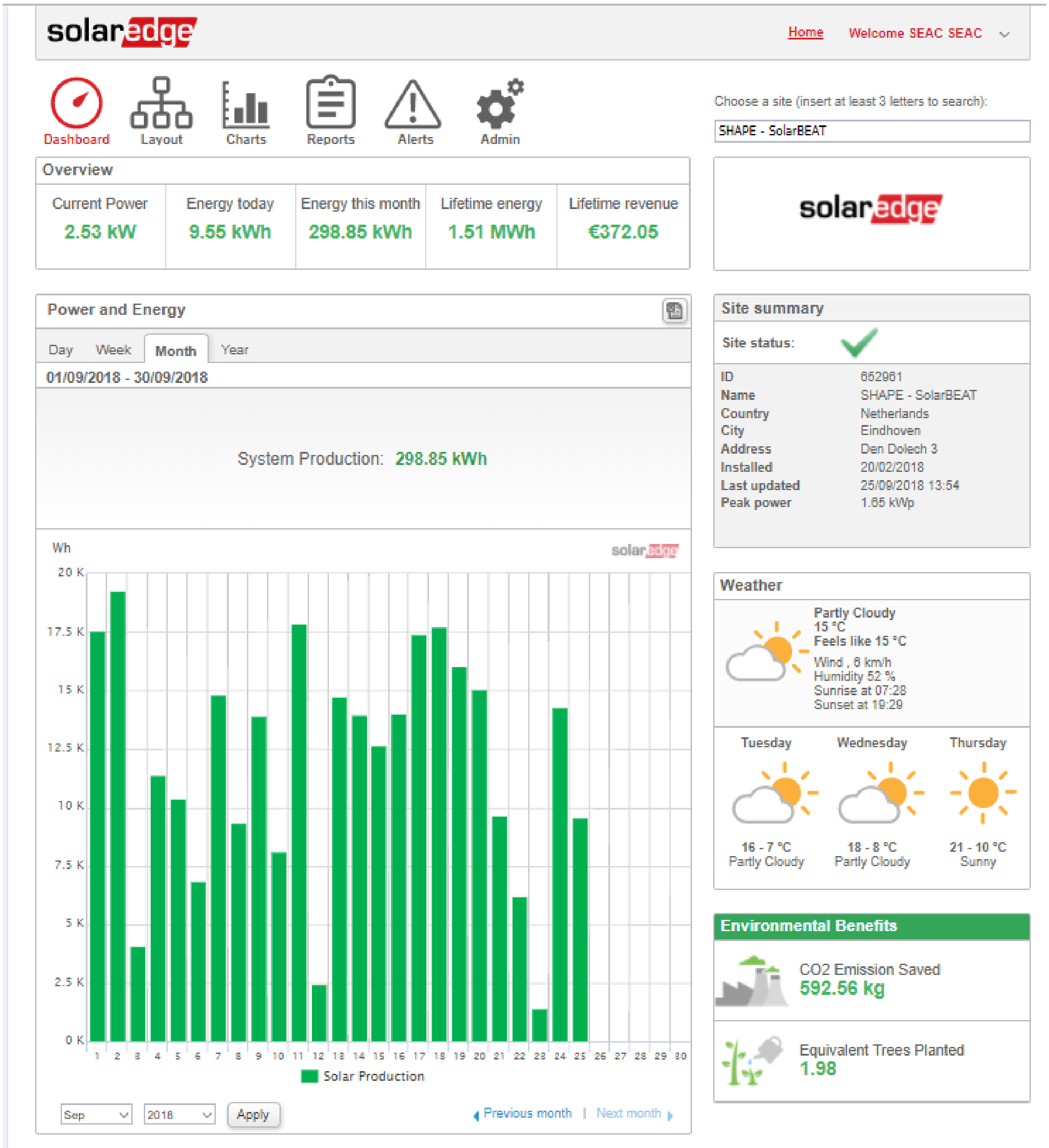


Figure 25: Screenshot of Monitor Portal. SolarEdge taken as an arbitrary example.

In the unlikely event that this option is not available, then we recommend to install an AC-kWh meter. TNO-SEAC would prefer the kWh-meter of company UPP, because other projects are also equipped with this kWh-meter; see Figure 26.

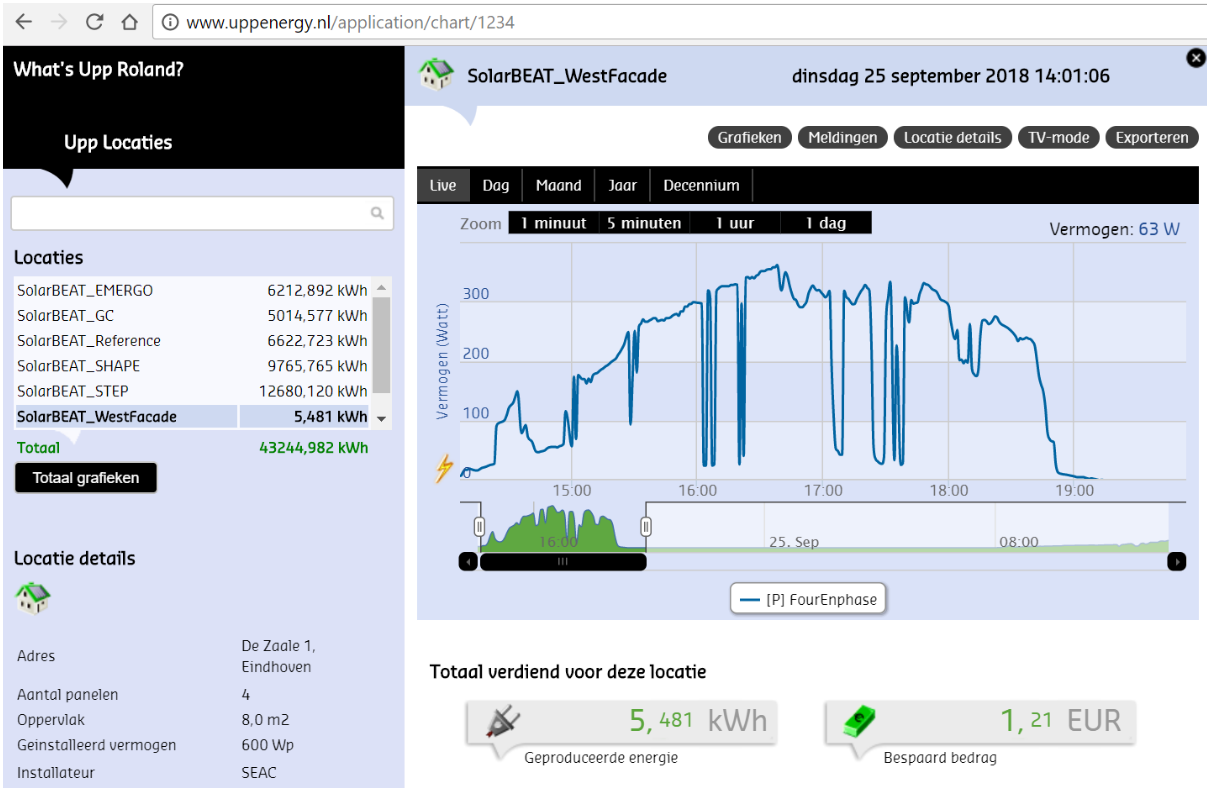


Figure 26: Screenshot of UPP kWh-measurement.

Because both options provide their data on a website, TNO-SEAC can do the analysis in Eindhoven, the Netherlands, even if the WP5.1 demonstrator is far away in Austria. Please note that a stable internet connection is mandatory.

4.3.2.3 Irradiance Measurement Equipment

In WP3.1 the highest quality irradiance sensor is used, which is a secondary standard pyranometer, EKO MS-802. For the WP5.1 demonstrator this would be superfluous. Either a first class pyranometer (like e.g. EKO MS-60) or a secondary class pyranometer (like e.g. EKO MS-40) would be good enough.

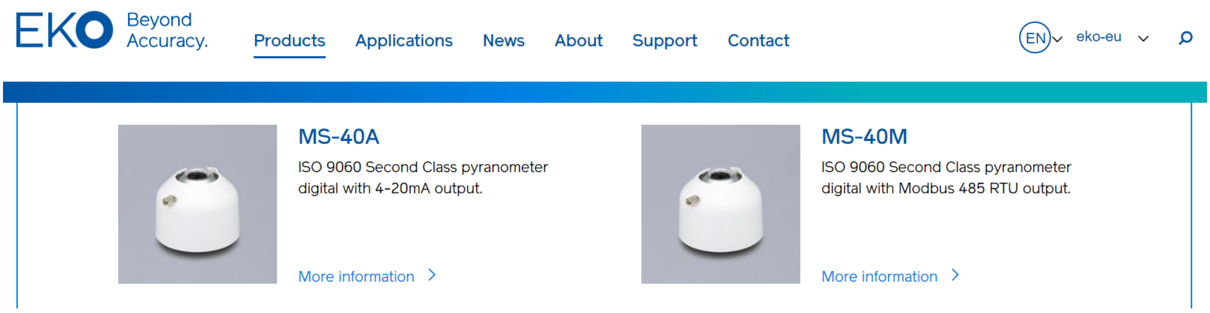


Figure 27: Secondary class pyranometer as irradiance sensor.

This pyranometer needs to be installed on a representative spot in the façade. That can be on many locations. One likes to stay away from the lowest part of the façade, where shading could have an impact. The precise location of the pyranometer will be determined during the next upcoming field trip in November 2018. Finally, the data from this pyranometer needs to connected to a data logger (either by analog connection or by digital MODBUS 485 RTU) or directly to the inverter. Again this will be decided on the field trip in close collaboration with the local electrical installer.

4.3.2.4 Weather Data Equipment

Finally, it is advised to have good quality weather information. This could be from the nearest official weather station from an Austrian meteo institute. Still to find out what is public available from this institute. Moreover, it will be investigated if the building has already a weather station (often this is the case for controlling blinds and other building climate systems). If none of the above is readily available, then a small weather station needs to be installed in the façade itself. This will be discussed with the local electrical installer.

Figure 28: Weather station Lufft WS600 of which TNO-SEAC has good experience. Please note: this is just an example! many high quality weather stations are available.

4.4 KPIs

With reference to the APPENDIX C of the D5.1 “KPIs plan for monitoring and assessment of the technologies at demo site levels”, has been following reported a list of KPIs that will be calculated. At this stage of design Baseline (B) no KPIs will be calculated in the Pilkington demonstrator. The table, reported below refers to the KPIs for the Post Renovation stage (P).

Name of demonstrator	KPI type	Progressive number	Design stage
Pi	Elc	3	P
Pi	Pv_Eff	1	P

Table 6 – Pilkington’s Demonstrator Generic and Specific KPIs – List

Considering that the Pilkington demonstrator does not have energy consumptions before renovation, all the KPIs will be calculated and included in the deliverable 5.3.

5 Conclusions

5.1 Savona demonstration

Savona demonstration is quite different from the other ENVISION demosites. Indeed in Savona will be mainly tested the system performances and their interactions with a Smart Polygeneration Grid. Regarding façade solar panels the test rig aims to understand how the panel performances (influenced by outdoor) affect the heat pump efficiency; coupling this system with the mGT it will be instead possible also to understand the impact of the system on a District Heating Network. On the other hand, considering the ventilated windows test-rig, all the performances evaluated are related to the building and room behaviour under the operational period of the windows. So it is possible to assume that Savona represents a complete demosite, where both outdoor and indoor parameters must be considered. System performances are evaluated mainly under an energetic point of view, therefore the most important parameters to be measured are mass flows, temperatures and electric consumptions. The indoor parameters (such as inlet air temperature, humidity) are instead the parameters considered for evaluating the ventilated windows performances. The outdoor parameters affect all the systems performances in terms of single technology (façade panels and ventilated windows) but also in terms of thermal loads (higher when outdoor conditions are particularly bad). In conclusions, all the cited parameters have to be measured and collected in order to study and understand how they interact each other. A good system management and design will guarantee the best results considering also the variations of the outdoor parameters during the year.
Renovation for this demosites consists mainly into the refurbishment of solar façade panels area but just in order to requalify the area without any direct link to ENVISION technologies installation.

5.2 Delft demonstration

In Delft the demonstration is applied to an apartment building originating from the 1950's, that has been renovated in the late eighties. At the time none of the nowadays available techniques existed. Therefore it is hard to compare the previous situation to the future.

Vestia is collecting as many data a possible from the situation before the Envision techniques will be applied, on usage of gas and electricity. An oversight of the environmental conditions, temperature, wind, solar impact will be included.

With all the meters and sensors mentioned in 4.2.3 installed insight in the energy usage in the end situation will be given. The quality of the comparison is strongly depending on theory. For instance, insulation will be improved and energy will be harvested from the panels. The weighing of these factors in their contribution of improvement of energy usage is a matter of concern and care.

Measuring equipment will collect online data of the indoor situation of the apartments and will continue to do so after the renovation is complete. This way a good comparison can be made of the indoor climate before and after.

5.3 Pilkington demonstration

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. Additionally, by extrapolation it will be possible to assess the performance in different climates around the European countries. The TNO Solar Energy Application Centre will monitor the demo and assess the performance, so that this extrapolation can be performed.

6 Abbreviation list

[ATO] - Antimony-doped Tin Oxide
[BIPV] – Building Integrated Photovoltaic
[CR] - Concentration Ratio
[COP] - Coefficient of Performance
[CCF]-Cumulative Cash Flow
[DHW] - Domestic hot water
[DHN] – District Heating Network
[EER] - Energy Efficiency Ratio
[ES]-Energy Signature
[EU]-European Union
[GUE] - Gas Utilization Efficiency
[HSPF] - Heating Seasonal Performance Factor
[HVAC] – Heating Ventilation Air Conditioning
[IGU] – Insulated Glass Unit
[IESL] – Innovative Energy System Laboratory
[IRR] - Internal rate of return
[KPI] - Key Performance Indicator
[mGT] – micro Gas Turbine
[NCF] - Net Cash Flow
[NIR] – Near Infrared Reflectance
[NCF] - Net Cash Flow
[NVP] - Net Present Value
[OPE] - Operating Expenses
[PMV] - Predicted Mean Vote
[PBP] - Payback period
[PPD] - Percentage of Person Dissatisfied
[PV] - Photovoltaic system
[PVB] – PolyVinilButiral
[RES] - Renewable energy system
[SEER] - Seasonal Energy Efficiency Ratio
[SEAC] – Solar Energy Application Centre
[SPM] – Smart Polygeneration Microgrid
[TRL] – Technology Readiness Level
[TSA] – Total Solar Absorbance