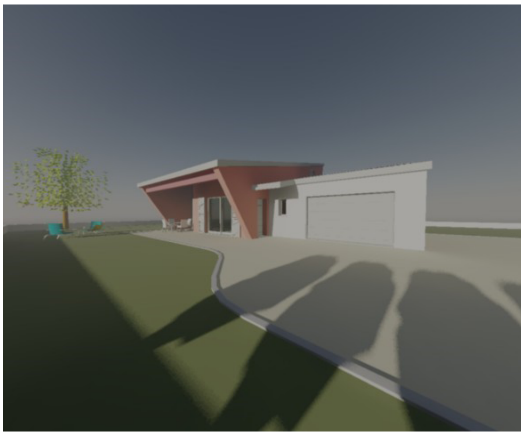
zero+

Achieving near Zero and Positive Energy Settlement in Europe using Advanced Energy Technology



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ECO. DEEPER THINKING
Opac38
CONTEDIL
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This project has received funding from European Union´s Horizon 2020 research and innovation program under grant agreement No. 678407.

Introduction

ZERO-PLUS is a collaborative approach to the design and construction of residential settlements, involving technology providers, energy efficiency and renewable energy experts and developers who work together from the earliest stages of design.

The goal is to provide the market with an innovative, yet readily implementable system for Near or Positive Energy settlements that will significantly reduce their costs. The benefits of the analysis at the settlement level arise from looking at the larger scale compared to single buildings, and at a system of houses with their inter-actions.

ZERO-PLUS settlements exceed the state of the art by setting performance objectives requiring improvement relative to other energy efficient buildings:

- Operational energy usage in residential buildings in a ZERO-PLUS settlement is reduced to an average of 0-20 kWh/m^2 per year

- The Net Zero Energy (NZE) settlement generates a minimum of 50 kWh/m^2 of renewable energy per year

- The investment cost of the ZERO-PLUS building is reduced by at least 16%, compared to a regular Net Zero Energy Building (NZEB).

The project is at a stage where design has been completed and work is entering the implementation phase. By the end of the project four ZERO-PLUS settlements will be built. They are located in different countries (Cy-prus, France, Italy and the UK) and consist of different typologies of residential buildings (ranging from villas to apartment buildings for social housing) thus demonstrating the adaptability and wide applicability of the ZERO-PLUS concept.

This booklet presents the main outcomes of the ZERO-PLUS projects on its second year emphasizing more on the final design and selected technologies for the four settlements and the planning for realisation.

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Case Studies

UK Case Study - Derwenthorpe, York

The UK case study is Derwenthorpe, located on the edge of the city of York, see Figure 1 and Figure 2. The case study, located in the North of England experiences a temperate climate, resulting in average winter temperatures between 1°C and 5°C, and average summer temperatures between 11°C and 18°C.

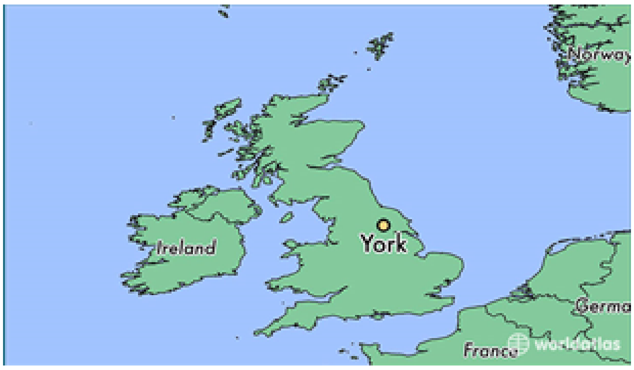


Figure 1. Location of the UK case study


Figure 2. Site plan for the UK case study

As a result of these climatic conditions there is a greater focus on heating demand in properties, with a total of 1975 heating degree days compared to 298 cooling degree days.

The Derwenthorpe settlement will consist of 489 dwellings of various house types. For the ZERO-PLUS project, a total of three properties will be built to meet the project targets. The ZERO-PLUS dwellings are representative of typical UK homes including two, two-storey semidetached properties and one two storey detached property, see Figure 3. In addition to the three dwellings that are part of the project, other parts of the settlement will be used to support the renewable energy targets of the project.


Figure 3. Architectural view of the UK case study

The concept of the UK case study is to create a sustainable community through a settlement level approach for energy generation in order to retain the traditional characteristics of a Derwenthorpe home. Energy reduction targets are achieved at the dwelling level, with renewable energy generation targets achieved at the settlement level, which in turn contributes to the cost reduction target.

Table 1 gives an overview about the main characteristics of the two building for the UK case study.

Table 1. Overview of the building parameters for the UK case study

General information	**Building Type B3**	**Building Type C4**
Total floor area	101 m²	156 m²
Net floor area	84.4 m²	129.6 m²
Orientation of the building	North-East (front face)	North-East (front face)
Storeys	2	2
Bedrooms	2	3
Thermal transmission coefficients		
U-Values of walls	0.17 W/(m² K)	0.17 W/(m² K)
U-Values of roof	0.16 W/(m² K)	0.16 W/(m² K)
U-Values of floor	0.14 W/(m² K)	0.14 W/(m² K)
Other specific parameters		
Shading	None	None
Type of glazing	Double (U-Value = 1.33)	Double (U-Value = 1.33)

Selection process of the technologies used in the UK case study

For energy reduction in the dwellings, standard UK produced external insulation will be used in lieu of ZERO-PLUS partner insulation product due to cost justification. For energy generation at the settlement level the ZERO-PLUS partner renewable system, Wind Rail®, will be installed, as it is the only ZERO-PLUS partner system compatible to the arrangement of the settlement, the needs of the dwellings and the UK climate. In addition, to meet the energy generation requirements of the ZERO-PLUS project, a large PV array will be mounted on the roof of the energy centre at the Derwenthorpe development. The energy centre is where the district heating base is located for the development; therefore, it is strategically positioned to support energy generation technology for the development.

Dynamic thermal modelling was used to analyze the impact of insulation and the need to meet thermal requirements of the dwellings. Specifically, each dwelling type was modelled in Integrated Environmental Solutions Virtual Environment (IES VE)[1] suite of software, specifically ModelIT for modelling the external physical characteristics of the dwellings and Apache for setting thermal parameters and running simulations. In Apache the thermal conductivity and thickness of each material was entered into the software for the respective elements of the building fabric. Following simulation of the fabric in association with heating system efficiency, modelled occupant behavior and weather data, the final consumption of the dwellings was checked against the primary ZERO-PLUS key performance indicator: reduce the operational (net-regulated) energy usage in residential buildings to an average of 0-20 kWh/m² per year. Though a number of insulation options could meet this, ultimately, cost analysis of material, shipment, and installation justified the use of insulation products, which could be locally sourced.

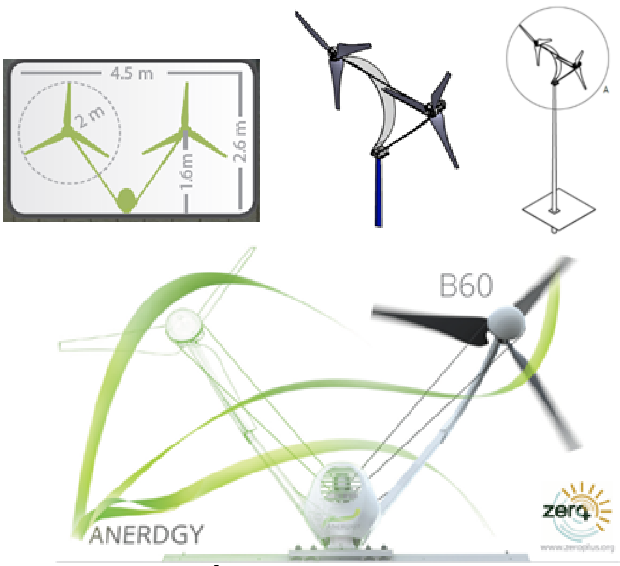


Figure 4. WindRail® B60 system as the mast mounted version

The production of the WindRail® system is calculated using the bespoke modelling tool provided by ANERDGY. The tool calculates solar (not applicable here) and wind generation based on weather data (hourly wind speed and direction) provided. Due to planning requirements, the typical double rotor horizontal axis WindRail® B60 arrangement (roof mounting) is not possible; therefore, the case study owner has been working with the technology provider to design a single mast mounted version of the WindRail® B60, see Figure 4. This version will include only the wind turbine, which is able to produce power not only during nice weather but also in bad weather conditions. The WindRail® B60 will produce an estimated 898 kWh of electricity annually. This is a 3 kWh/m² contribution to meet the 50 kWh/m² settlement generation requirement. All specifications of the WindRail® B60 system are summarized in Table 2.

Table 2. WindRail® B60 general specifications according to ANERDGY

Manufacturer	ANERDGY AG	**Cut-out wind speed**	20 m/s
Model no	B60 W H	**Rotor speed range**	0 - 450 rpm
Description	Dual horizontal axis micro wind turbine	**Speed reduction method**	Power curve deviation & security brake
Weight turbine unit	90 kg		
Rotor diameter	2 x 2.0 m	**Yaw control**	Wind vane & lee runner
Rotor swept area	2 x 3 m² = 6 m²	**Blade pitch control**	Passive spring mechanism
Number of blades	2 x 3 = 6	**Blade specification**	PUR form
Hub height	1.6 m	**Generator type**	Permanent magnet servo drive
Wind class	III	**Power conversion**	Integrated in drive – DC 100-400 V out
Rated power	1500 W	**Turbine Controller**	ANERDGY TCU-400
Rated wind speed	10 m/s	**Inverter Type**	e.g. Steca coolcept 2kW 1-phase
Survival wind speed	37 m/s	**Grid protection method**	Inverter integrated
Cut-in wind speed	3 m/s		

[1]IES VE thermal calculation and dynamic simulation software was selected as it is an approved industry standard, audited by the Chartered Institution of Building Services Engineers and the United Kingdom Accreditation Service as well as being an accredited software for producing Energy Performance Certificates (EPCs) by the Building Research Establishment (BRE).

The PV will produce an estimated 16,000 kWh of electricity annually. This is the remaining 53 kWh/m^2 contribution to exceed the 50 kWh/m^2 settlement generation requirement. The PV installer performed the calculation of expected generation and export, including expected Feed-in Tariff earnings.

HIVE active heating, smart home system, see Figure 5, will be installed to serve as an energy management tool for the occupants of the dwellings. HIVE will allow smart home learning for ideal heating, and remote control of heating lighting and select appliances. The HIVE active heating system allows users to control heating and hot water from their smartphone, tablet or laptop. The system allows add-ons for home power management including lighting, home motion sensing, window and door sensing and smart socket controls for any appliance. Dynamic thermal modelling resulted in an estimated 5% reduction in heating fuel consumption and a 10% reduction in lighting energy consumption.

Figure 5. HIVE active heating thermostat control
(image from https://www.hivehome.com/products/hive-active-heating)

The insulation stands alone to first and foremost reduce consumption at the base level: conservation of heat. The HIVE home energy management system improves further the energy conservation in the dwellings by allowing the user to control the magnitude and timing of heat consumption at a fine detail. The HIVE home energy management system is a wireless thermostat control device that communicates with a hub that is connected to homes broadband router, and the receiver which allows the thermostat to communicate with the boiler. HIVE allows for more detailed control over the heating system while away from home.

The unique quality of HIVE is that it comes with an online app. The app allows:

- Heating control: Switch heating on and off, up or down; the boost button allows extension of heating outside of regular schedule
- Hot water control: Turn hot water on and off; the boost button allows extension of water heating outside of regular schedule
- Geolocation: Based on the user's phone location, HIVE will send reminders to turn heating on before arriving at home, or off if left it on accidently
- Heating & hot water schedules
- Frost protection: To help protect pipes from freezing, HIVE automatically activates when the heating is off and the temperature inside your home dips below 7°C.

The renewable energy systems are not directly interrelated with the insulation or HIVE as the dwelling uses natural gas for space and water heating and electricity or other non-regulated loads. The energy generated by the PV and WindRail® B60 will be consumed by the dwellings when possible. When generation outperforms demand, batteries (sized to the system) will store excess generation. If and when generation outperforms demand and battery capacity, the excess generated energy will be exported to the grid.

In Table 3 the technologies selected for the UK case study are summarized.

Table 3. Overview of used technologies, their function and expected performance

Case study: Derwenthorpe, UK				
Technology	**Installation location**	**Function**	**Performance**	**Number of units**
Webertherm XM	External wall insulation	Conservation of heat	-	-
HIVE smart home management system	Dwelling	Energy management	Potential 5% reduction in heating consumption	1 per dwelling
WindRail® B60	Settlement level	Energy production	898 kWh/year	1
Photovoltaic panels	Settlement level (energy centre)	Energy production	16,000 kWh/year	est. 64 panels
ABB monitoring and storage	Resource management	Energy storage	-	1

Implementation of the technologies selected for the UK case study

Webertherm XM - External Wall Insulation

Webertherm XM is a high performance external wall insulation system protected by meshcloth reinforced polymer renders, see Figure 6. Webertherm has been used in the UK case study in lieu of Fibran XPS as when it is applied to a masonry substrate it provides BBA certification.

The features and benefits of webertherm are:

- Provides efficient thermal insulation for refurbishment and new build projects
- Comprehensive range of colours and textures enable the creation of striking visual effects
- Has a high performance water shedding range of finishes to protect the building fabric
- Low K-value insulants allow thinner insulation to be used or higher standards to be achieved
- Eliminates interstitial condensation by creating a ‚warm wall' construction
- Suitable for, and effective on most buildings including lightweight steel frame structures and in-fill panels
- Supported by comprehensive technical and architectural services.

Weber External Wall Insulation is traditionally maintenance free but to ensure the optimum life, aesthetics and thermal efficiency, there are a number of guidelines around fixing items to the wall, the use of ladders, and cleaning requirements for the render.

HIVE Active Heating and Home Energy Management

The HIVE Active Heating thermostat will be installed as part of the wider HIVE Home Energy Management System. In addition to the heating control this includes HIVE Active Sensor, HIVE Active Plug and HIVE Active Light.

HIVE Active Heating allows the user to control their heating from a smartphone with our beautifully designed thermostat.

The main features of the HIVE Active Heating are:

- Ability to turn heating on remotely
- Schedules set by learning algorithms to ensure correct temperatures at the right times.

The HIVE Active Heating also links through HIVE Actions to other HIVE products, such as the HIVE Active Sensor, to allow the heating to be turned on when the front door is opened.

The HIVE Energy Management system consists of:

- *HIVE Window or Door Sensor*, which provides notifications if a door or window is opene when you are away and works with HIVE Actions to save on heating and lighting.
- *HIVE Active Lights*, which allow lighting to be set to schedules brightness levels, with the ability to save energy by controlling lights remotely.
- *HIVE Active Plug*, which allows for Control from smartphone, tablet or laptop and to schedule appliances to switch off automatically.

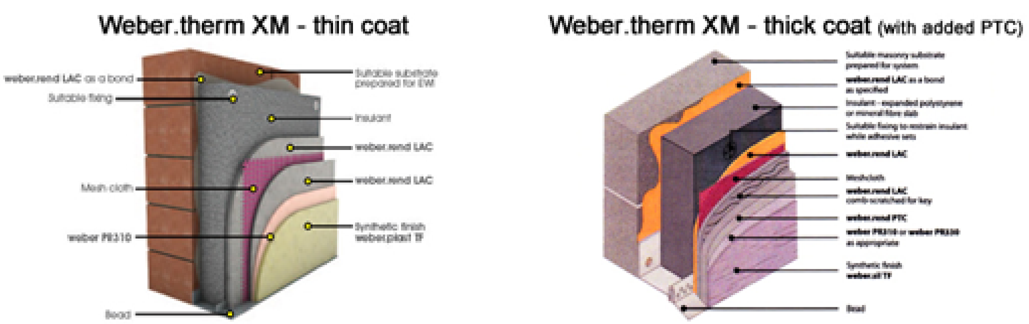


Figure 6. Webertherm XM insulation system (image from www.weber.ie)

WindRail® B60

The WindRail® B60 wind turbine, manufactured by ANERDGY AG, a ZERO-PLUS project partner, will be one of the key ZERO-PLUS technologies used in the UK case study. The WindRail® B60 has been developed from the ground up and it stands out, not only through its striking looks, but as well as through its high efficiency and unsurpassed safety system. The WindRail® B60 system consists of two parts: the dual horizontal axis micro wind turbine and the mounting system. It can be installed on the pitched rooftop of the building or on a mast structure.

In order to meet the planning requirements associated with the use of on shore wind in the UK, the most appropriate solution is to use a mast mounted turbine.

The typical design for the WindRail® B60 provides integration of solar PV and wind technology to maximise energy generation. However, with the use of the mast system the integration of PV is not feasible. For the UK case study PV will be installed in a separate installation on the roof of the nearby energy centre.

The WindRail® B60 system and the mast structure will be installed near the front side of the Communicate centre building, see Figure 7 and Figure 8.

Before final on-site installation of the WindRail® B60, the following aspects need to be addressed:

- Acoustic measurements of the system
- Shadowing impact on site and on neighbors (daylight and sunlight analysis as well as shadow fall impact will be required by the City of York Council)
- Bird and wild life protection
- Biodiversity report (may be needed)
- Visual impairment on the adjacent nature (survey of the residents will be done by the council and possible objections will be considered)
- Submission of all documents by the project architect.

The installation and assembly procedure for the WindRail® B60 has been both well-considered and made simple. The WindRail® B60 system will be delivered disassembled in transportable items on a europallet and mounted on a mast structure within the settlement. Therefor, the T087RLH/FP mast type designed by Abacus, a manufacturer based in the UK, according to the requirements specified by ANERDGY, will be installed first, see Table 4.

Figure 7. Proposed installation location

Figure 8. Architectural impression of the proposed installation location

Table 4. Production information T087RLH/FP heavy duty base hinged mast

Production information T087RLH/FP Heavy duty base hinged mast				
Height	**Weight**	**Shear (kN)**	**OTM (kNm)**	**Concrete dimension**
6m	122kg	2.3	14.6	S=950 x H=1100
Note: Concrete dimension based on a minimum ground bearing pressure of 150kN/m², (S = square dimension, H = depth). OTM: overturning moment				

The mast structure has a base-hinged feature, which can be easily lowered and raised by using industry-standard tools, see Figure 9. The flange plate will be mounted on to a precast concrete foundation base, see Figure 10. Finally, the installation of the electrical wiriring and connections will be installed and the WindRail® B60 system will be mounted.

The Installation of the WindRail® B60 turbine will be carried out by a registered UK installer. Under UK microgeneration regulations, installers of renewable energy are required to be accredited to the Microgeneration Certification Scheme (MCS). An MCS installer, overseen by ANERDGY, will undertake the site installation and commissioning process.

For the maintenance purpose of the WindRail® B60 mast mounted system, in the base section of the mast, there is an opening featuring a flush door. The flush door provides easy access to the cables and equipment inside the pole. This feature will increase work efficiency when carrying out cable repair or replacement work. The flush door also comes complete with a locking device, for which the maintenance engineers will be issued keys in order to prevent vandalism, cable theft, and anti-social behaviors. A cable duct in the underground section of the mast allows the cables to run through the pole. The mast can be easily lowered and raised when maintenance work is required for the WindRail® B60 system, see Figure 9.

The ANERDGY WindRail® B60 is designed for 20 years plus operation and the maintance activities are minimal and consider mainly the power train: rotors, toothed belt and gears. To ensure fulfil the long-term operation a set of maintenance activities is required:

- A-Inspection: Yearly; visual check about the dirt and insects and cleaning.
- B-Inspection: every 5 years: A inspection +Operation check, lubrication, belt check, blade check.
- C-Inspection: every 10 years: A-B inspection + replacement belt + blades.
- D-inspection: every 20 years: A-C inspection + full refurbishment, Drive unit parts & mast elements replacement.

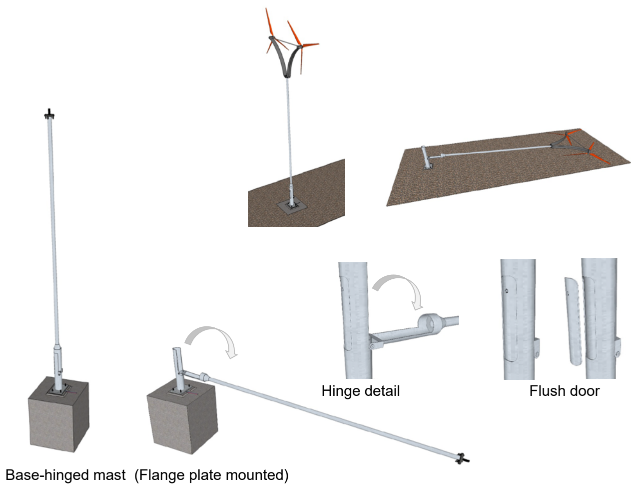


Figure 9. Base-hinged mast system detail and maintenance method

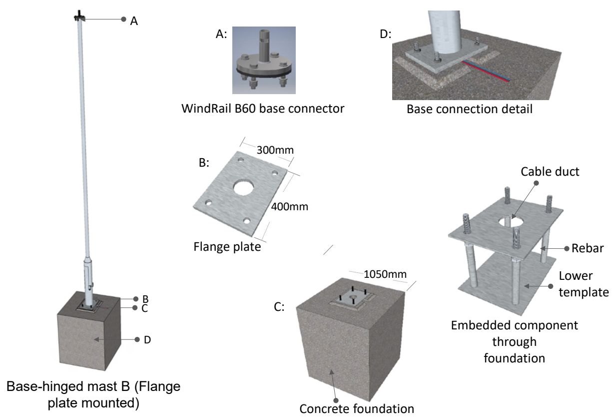


Figure 10. Base-hinged mast base connector and foundation detail

Monitoring and Evaluation of the technology performance

In the case study of UK, two energy production technologies are going to be installed, a WindRail® B60 turbine and PV panels at the energy centre roof.

The mathematical model, that describes the calculation of energy production as a function of the relevant environmental parameters, was defined for both technologies. The purpose of the models is the prediction of energy production to support maintenance of the technologies. The WindRail® B60 mathematical model was created by the manufacturer, has as input the wind speed and direction, and outputs the electrical power. The PV panel's mathematical model is based on the free library PV_LIB by Sandia National Labs and has as input the specifications of the PV panels, orientation, date, time, global solar radiation, ambient temperature, wind speed and outputs the electrical power. Currently, the link of the prediction models with the Web-GIS platform (see "Design of a monitoring framework for performance assessment during operation") is in progress.

Furthermore, the monitoring equipment for recording and transferring performance data of the energy production technologies to the Web-GIS platform has been selected. The inverter that will be used to connect both the WindRail® B60 and the PV panels to the UK national energy grid will be used to measure the energy production.

The commercial monitoring equipment that will measure indoor environmental quality and energy consumption of the buildings has been selected according to the specifications that have been set (see "Design of a monitoring framework for performance assessment during operation").

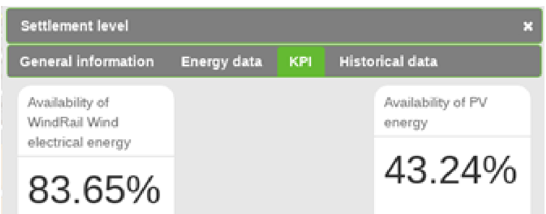


Figure 11. Example screenshot of the KPI's as displayed on the Web-GIS

The specifications have been set by the project's technical committee to ensure the correct measurement of the Net regulated energy (one of the KPIs of the project, Figure 11), and thermal comfort of the residents of the settlement. The following measurements will be gathered:

- Room temperature, relative humidity, carbon dioxide concentration
- Energy for heating, domestic heat water
- Energy production by RES and consumption by apartment.

Periodically spot measurements will be taken for the space illuminance and Volatile Organic Compounds (VOCs). Also, a meteorological station will be installed in the premises of the settlement in order to measure the meteorological conditions of the area.

The installation, post-installation and post-occupancy measurement and verification procedures for the thechnologies have been defined in the Measurement and Verification plan of the project. These procedures at installation and post-installation phases coincide with the Commissioning Plan that has been prepared within the ZERO-PLUS project. For the post-occupancy phase, fault detection has been designed and will be incorporated in the Web-GIS platform. Furthermore, reasons of unsatisfactory performance will be detected through a Problem Identification procedure, Figure 12.

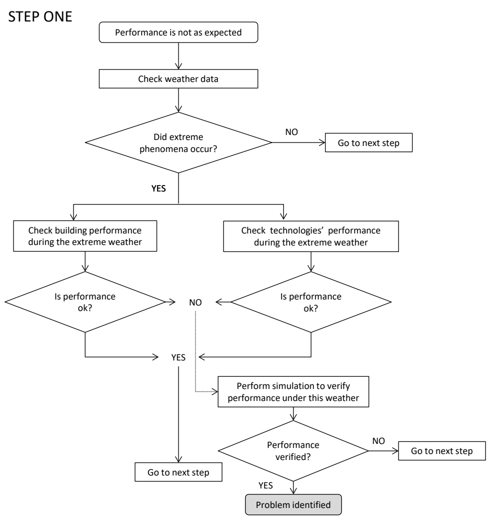


Figure 12. The first step of the problem identification procedure

Italian Case Study - Granarolo dell'Emilia

The Italian case study is part of a housing development area already under construction in Granarolo dell'Emilia (BO), located at 28 m a.s.l. in Emilia-Romagna (Center-East of Italy, 44.549 N – 11.452 E), see Figure 13. The flat area covered by the project include the two demonstration single-family villas that will be built following the guidelines given by ZERO-PLUS in order to reach a Net Zero Energy (NZE) settlement. In particular, the total area dedicated to the demonstration case study, i.e. two NZE buildings and close surrounding financed by the ZERO-PLUS project, is close to 2760 m^2. The surrounding area is a residential area rich in social services (e.g., schools, administrative offices, stores, banks, etc.) and public transportation utilities. In addition, it is close to a public green area.

Figure 13. Location of the Italian case study

The case study belongs to the climatic zone E (2162 heating degree-days and about 110 cooling degree-days) and is characterizated by temperate and Mediterranean climate. Along the year, the average maximum temperature is 24.6°C, while the average mimimum temperature is 2.5°C.

The total area covered by the project is approximately 9600 m^2 (not including public spaces). Here, eight single-family villas will be built, including the two demonstration high-energy efficient single-family villas characterized by a similar architectural design (i.e. one ground floor villa and one two-floors villa), see Figure 14. The standard ground floor villa has one kitchen, one living room, one hall, two bathrooms, three bedrooms, one utility room, and a private garage. Each villa has private access and garden, which become a connected area within the settlement. The villas are located each one in one lot. The total floor area of each villa is about 240 m^2 distributed into an approximately rectangular ground sub-lot of about 800 m^2. The entrance is oriented to the North-West side of the lot. The accommodations are designed to host one family of about three to five people. Two families can be hosted in the whole small district, which presents the typical Italian residential scheme.

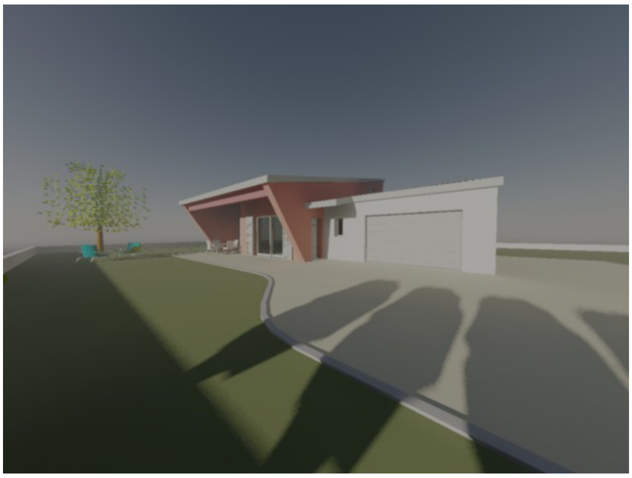


Figure 14. Architectural view of the UK case study

The two demonstration villas will be built within a growing urban area belonging to an on-going regeneration local program. The entire neighborhood has been thought to being built following the guidelines given within the framework of ZERO-PLUS project with the aim to improve the microclimatic conditions, the livability, and the energy efficiency of the entire area. Table 5 summarizes the main characteristics of the two building typologies in the Italian case study settlement.

Table 5. Overview of the main characteristics of the buildings in the Italian case study settlement

General information	**Villa A**	**Villa B**
Total floor area	241 m2	259 m2
Net floor area	118 m2	131 m2
Orientation of the building	North-West	North-West
Storeys	1	2
Bedrooms	3	3
Thermal transmission coefficients		
U-Values of walls	0.120 W/m2 K	0.12 W/m2 K
U-Values of roof	0.117 W/m2 K	0.117 W/m2 K
U-Values of floor	0.167 W/m2 K	0.167 W/m2 K
Other specific parameters		
Shading	Traditional blinds	Traditional blinds
Type of glazing	Low-e double glazing 3+3/13 mm with argon, 0.17 for windows	Low-e double glazing 3+3/13 mm with argon, 0.17 for windows

Selection process of the technologies used in the Italian case study

In the Italian case study, following technologies were selected: ANERDGY WindRail® B60 for energy production at settlement level; PV panels for energy production at both building and settlement level; FIBRAN insulation for energy conservation at building level; ABB REACT+ for energy storage at both building and settlement level; ABB Load Control for energy management; ABB Home Energy Management System for energy management at building level.

In order to calculate the performance of each selected technology, different analysis methods were used. The energy production by WindRail® B60 was calculated through a tool provided by the technology producer (i.e. ANERDGY). The calculation required the following hourly input parameters for a whole year: wind speed, wind direction, and global solar radiation, in the case study location, in addition to the technology characteristics. The input climate data used in the calculation were provided by MeteoBlue. On the other hand, the energy produced by the PVs and the achievable energy conservation through the installation of FIBRAN insulation were analyzed via building thermal-energy dynamic simulation. The numerical analysis was performed within EnergyPlus simulation environment with DesignBuilder graphical interface. The TMY (Typical Meteorological Year) for the case study location was selected in the EnergyPlus weather file database as climate input data. Also, energy management systems were partially simulated via dynamic simulation through EnergyPlus. Finally, the two ABB REACT+ were selected for the storage of energy produced by the WindRail® turbine and the PV panels in the Italian case study settlement. Therefore, the two storage tanks were dimensioned based on the data of energy production by these two above-mentioned technologies.

The technologies implemented at building level, like FIBRAN insulation, HEMS and Load control by ABB, will contribute together for the energy conservation. PV panels at both building and settlement level will contribute with the WindRail® B60 at the energy production and will allow having renewable energy to be used at different time during the day.

The energy produced by the RES technologies (i.e. WindRail® B60 and PV panels) will be firstly used to cover the residents' consumers and the consumes of the houses itself, secondly to be stored in the energy storage to be used for private pourpouses when the RES technologies are not producing energy, and lastly the excess of energy will be provided to the national grid.

The selection of the ZERO-PLUS technologies was performed with the aim of achieving simultaneously the three main goals of the project in terms of energy production, energy consumption, and cost. In particular, the thickness of the insulation panels was optimized in order to reduce the predicted energy consumption of the two villas. The number of WindRail® B60 systems was reduced from two to one after the Life Cycle Cost analysis, while the number and typology of PV panels at building and settlement level were defined in order to reach the total amount of 50 kWh/m² y of energy production.

The Table 6 shows an overview of the technologies used in the Italian case study.

Table 6. Overview of used technologies, their function and expected performance

Case study: Granarolo dell'Emilia, Italy				
Technology	**Installation location**	**Function**	**Performance**	**Number of units**
WindRail® B60	Settlement level	Energy production	5.21 kWh/m² year	1
Solar PV	Building and settlement level	Energy production	48 kWh/m² year	44 panels for total 11 kWp
FIBRAN	Building	Energy conservation	1 kWh/m² year	220 mm walls 150 mm roof
ABB REACT+	Settlement level	Energy Management	-	2
ABB Load Control	Building	Energy Management	-	1 in each villa
ABB Home Energy Management System	Building	Energy Management	-	1 in each villa

Implementation of the technologies selected for the Italian case study

FIBRAN

The FIBRAN insulation system will be integrated into the wall and the sloped roof. In the sloped roof a thickness of 7 + 7.5 cm is planned, in the ground floor 10 + 5 cm and in the external walls 22 cm, see Figure 15.

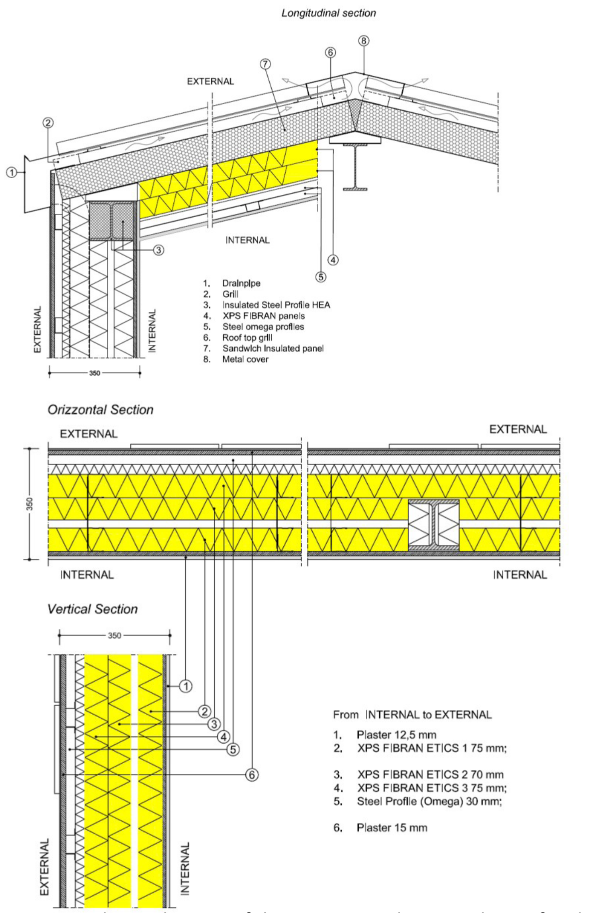


Figure 15. The application of the FIBRAN insulation in the roof and in the walls in the Italian case study

PV panels

In the Italian case study, altogether 44 polycristalline PV panels will be used for the energy production. 16 PV panels will be installed on the roof of each villa with 4kWp of total power producing 35 kWh/m^2 y. Further 12 PV panels will be mounted on the shelter for cars with 3 kWp of total power producing 13 kWh/m^2 y, see Figure 16.

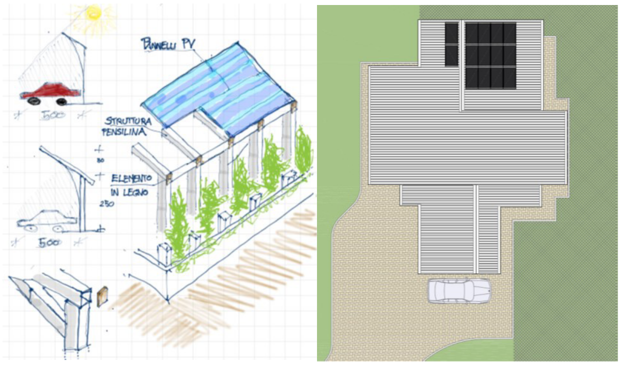


Figure 16. Location of the PV panels in the Italian case study

WindRail® B60

The WindRail® B60 system consists of two parts: the wind turbine and the roof mounting system. It can be installed on the pitched rooftop of a building but in the Italian case the WindRail® B60 system will be mounted on a mast structure at the settlement level, see Figure 17. The mast design should be similar to the T087RLH/FP heavy duty 6-12M base-hinged, flange plate mounted system from Abacus used in the UK case study. However, due to the distance between Abacus and the case study site the most feasible solution would be contacting a local suppler with the specific mast specifications. The local suppler need to comply with ISO9001 for all its activities, ISO14001 for environmental management, and ISO18001 for health & safety management systems.

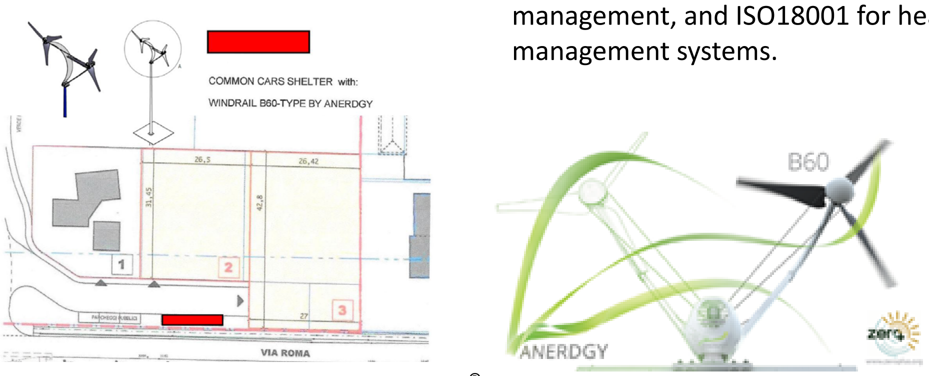


Figure 17. The integration of the WindRail®B60 system in the Italian case study

The installation and assembly procedure in the Italian case study is very similar to the UK case study. The case study owner will make sure the avilablility of the precase concrete foundation and if the ground condition is suitable for the final installation.

After the foundation pit and the cable supply trench have been excavated, the concrete foundation need to be prepared and poured. This is followed by the installation of the mast structure and then the assembly and installation of the WindRail® B60 system, see Figure 18.

As prior to any other construction project, planning permission and building regulations requirements will need to be checked with the local planning office. In addition, there are some aspects, which need to be considered, such as:

- Before the on-site activity starts, the project team must consult ground engineers to conduct a ground condition test in order to determine what the soil conditions are at the case study site;
- Before the installation of the system, wind has to be determined;
- Possible shadowing impact assessment will be conducted;
- Before the assembly begins, the following equipment is required: timber supports and packers, liquid soap, a column carrier, a mobile crane to erect the precast concrete base (typically 0.5 tonnes) and a torque multiplier and wrench. Note: Do not attempt to lower the mast if the wind speed is at or above 30 kph (18 mph).

The maintenance activities are minimal and mainly focus on the following areas, namely, rotors, toothed belt, and gears. ANERDGY recommends a yearly visual inspection about dirt and insects with cleaning – called A-check. The toothed belt, gears and rotors have a 10-year lifetime forcast called C-check. All 20 years a D-check has shall be performed.

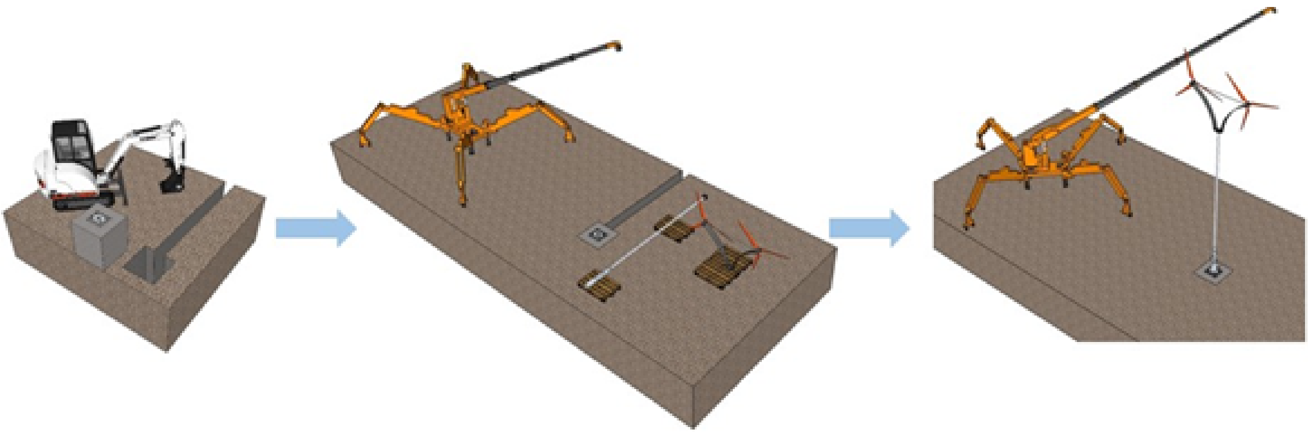


Figure 18. The WindRail® B 60 system installation procedure

Monitoring and Evaluation of the technology performance

In the case study of Italy two energy production technologies are going to be installed; a WindRail® B60 turbine and PV panels on the roof of each villa and on the roof of the common cars center.

The mathematical model, that describes the calculation of energy production as a function of the relevant environmental parameters, was defined for both technologies. The purpose of the models is the prediction of energy production to support maintenance of the technologies. The WindRail® B60 mathematical model was created by the manufacturer, has as input the wind speed and direction, and outputs the electrical power. The PV panel's mathematical model is based on the free library PV_LIB by Sandia National Labs and has as input date, time, global solar radiation, ambient temperature, wind speed and outputs the electrical power. Currently, the link of the prediction models with the Web-GIS platform (see "Design of a monitoring framework for performance assessment during operation") is in progress.

Furthermore, the monitoring equipment for recording and transferring performance data of the energy production technologies to the Web-GIS platform has been selected. The inverter that will be used to connect both the WindRail® B60 and the PV panels to the Italian national energy grid will be used to measure the energy production.

The commercial monitoring equipment that will measure indoor environmental quality and energy consumption of the buildings has been selected according to the specifications that have been set, (see "Design of a monitoring framework for performance assessment during operation").

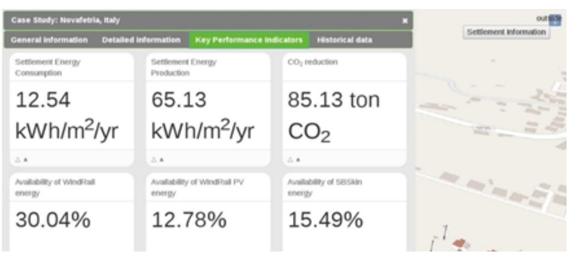


Figure 19. Example screenshot of the KPI's as displayed on the Web-GIS

The specifications have been set by the project's technical committee to ensure the correct measurement of the Net regulated energy (one of the KPIs of the project, see Figure 19), and thermal comfort of the residents of the settlement. The following measurements will be gathered:

- Room temperature, relative humidity, occupancy, illuminance
- Energy for heating, cooling and domestic hot water
- Energy production by RES and consumption by apartment.

Periodically spot measurements will be taken with a specialized microclimatic station for the verification of the measurements of the commercial monitoring equipment. In addition, a meteorological station will be installed in the premises of the settlement in order to measure the meteorological conditions of the area.

The installation, post-installation and post-occupancy measurement and verification procedures for the technologies have been defined in the Measurement and Verification plan of the project. These procedures at installation and post-installation phases coincide with the Commissioning Plan that has been prepared within the ZERO-PLUS project. For the post-occupancy phase, fault detection has been designed and will be incorporated in the Web-GIS platform. Furthermore, reasons of unsatisfactory performance will be detected through a Problem Identification procedure, see Figure 20.

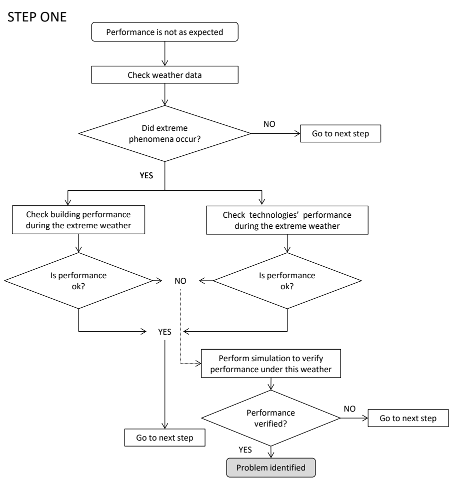


Figure 20. The first step of the problem identification procedure

Cyprus Case Study - Peyia

The settlement is located in the western part of Cyprus, near the town of Peyia (Paphos). It is in a rural area on a hillside location, with slope of a medium-steep 20-30%, see Figure 21. The climate in the area is intense Mediterranean, with mild winters and hot summers (T_{max} 36°C, T_{min}10°C).

The settlement size is 255,000 m², and it is divided in 3 areas: a rehabilitation center, a research center and a residential area, see Figure 22. The residential part of the development includes 95 individual houses and 9 apartment buildings. Under ZERO-PLUS project, two houses will be built which are individual residential luxury villas: Villa 1b of a building surface about 270 m² and Villa IIa of a building surface about 175 m², see Figure 23.

Figure 21. Location of the Cyprus case study

The two houses will be built within the above settlement with the scope to apply their design in the entire settlement, in order to improve the energy efficiency of the whole project.

Figure 22. Site plan for the Cyprus case study

There is also a need for the buildings within the settlement to be aesthetic appealing in order to compete in Cyprus contemporary and conventional house market.

Table 7 gives an overview about the main characteristics of the two villas for the Cyprus case study.

Table 7. Overview of the building parameters for the UK case study

General information	**Villa 1b**	**Villa IIa**
Total floor area	268.7 m²	174.1 m²
Net floor area	241.47 m²	163.56 m²
Orientation of the building	North-South	North-South
Storeys	2	2
Bedrooms	4	3
Thermal transmission coefficients		
U-Values of walls	0.386	0.386
U-Values of roof	0.352	0.352
U-Values of floor	0.644	0.644
Other specific parameters		
Shading	Overhanging slab extension / external shading in bedrooms	Overhanging slab extension / external shading in bedrooms
Type of glazing	Common LowE double glazing 2.40 0.56	Common LowE double glazing 2.40 0.56

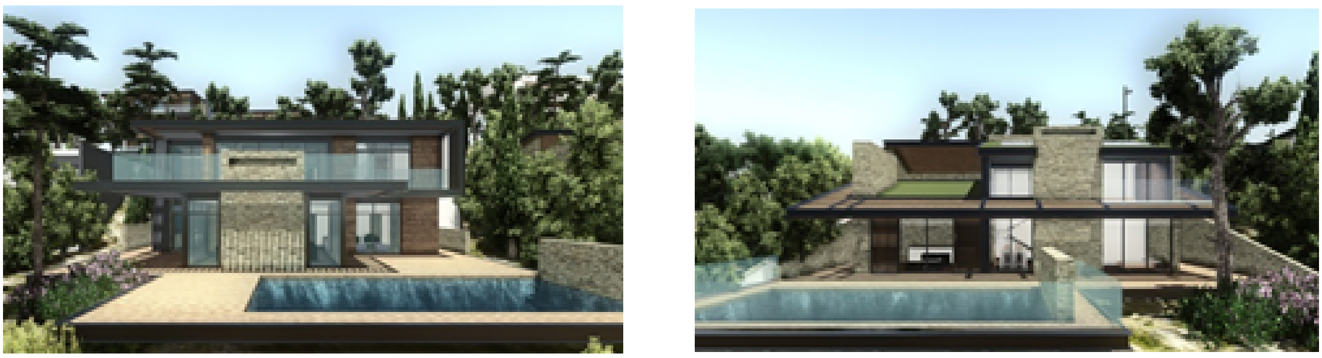


Figure 23. View of the Cyprus Villas: left villa 1b and right villa IIa (Images provided by UDS architects)

Selection process of the technologies used in the Cyprus case study

Innovative energy conservation and renewable energy generation technologies were applied and tested for the Cyprus case study, in order to achieve better results than conventional technologies do and a better integration of the technologies in the houses, which can help the installation and maintenance processes.

Advanced insulation provides a needed reduction in space heating and cooling for the case study buildings. In addition, one feature that makes the advanced insulation particularly important for Cyprus is that it is coated with a highly reflective surface material, which mitigates overheating risk. More specifically FIBRAN technology conserves 1525.73 kWh/year that is 3.77 kWh/m^2/year from the addition of 80mm FIBRAN insulation on the roofs and 1232.50 kWh/year that is 3.04 kWh/m^2/year from the addition of 40mm FIBRAN insulation on the walls.

Extruded polystyrene production is based on the extrusion of the mixture of raw material, with the appropriate blowing agents and fire retardant. The extrusion makes the molecular structure of the XPS to have almost 97% of closed shells. This is why XPS material has an extremely high resistivity towards water. Furthermore, the coherence of the structure provides a board with very high compressive strength. The innovation in the XPS production is the creation of a waffle surface, see Figure 24 which allows the best possible coherence between XPS and plaster or primer.

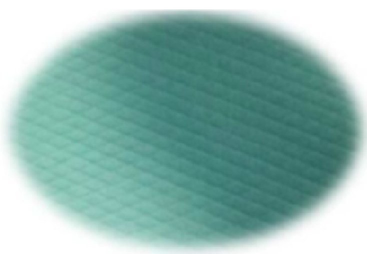


Figure 24. Waffle surface of Extruded Polystyrene board provided by FIBRAN

HVAC Freescoo is an innovative compact solar air conditioning system. It is designed for ventilation, cooling, dehumidification and heating of buildings, see Figure 25. The system is based on a new solar Desiccant Evaporative Cooling (DEC) concept. Solar heat and water are used to drive the cooling process that conditions the space the unit is connected to. The air handling process ensures temperature and humidity control. In addition, the system is designed to provide air flow in the conditioned space.

The HVAC Freescoo technology has an important energy conservation of 12002.83 kWh/year for both villas that is 29.64 kWh/m^2/year. Moreover, the fuel that the HVAC Freescoo technology uses for heating is the hot water provided by the FAE technology and the fuel that it uses for cooling is the electricity provided by the same FAE technology.

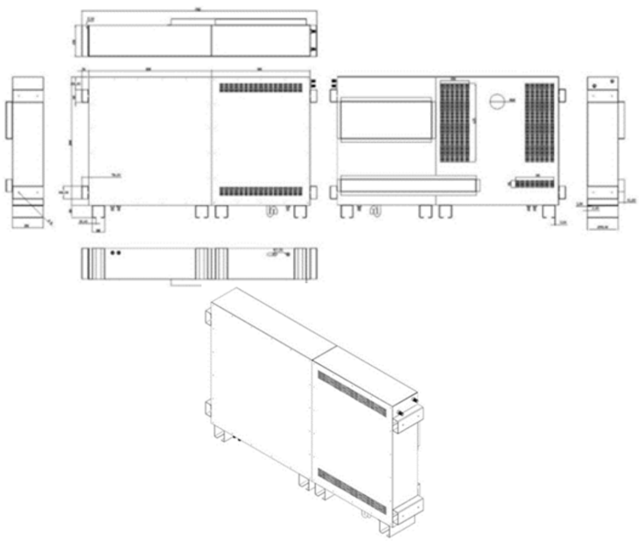


Figure 25. HVAC Freescoo provided by Solarinvent

The FAE HCPV developed by IDEA, associated to ARCA Consortium, is a technology, which exploits solar radiation to generate electricity and heat at the same time, with a high combined efficiency. A non-image optic system is concentrating the sunrays on multifunction cells that are actively cooled on their backside. An array of 20 of such receivers are integrated upon a double-axis tracking system that is precisely following the position of the sun, see Figure 26. To maximize the energy harvest of the FAE HCPV system the main axis must always be oriented in a north-south direction.

Figure 26. FAE HCPV developed by IDEA

The FAE HCPV technology generates electrical energy of 9171.41 kWh per year, while it also generates 12070.84 kWh thermal energy per year, which, as mentioned above, can be used by the HVAC Freescoo technology, see Figure 27. It therefore generates 52.46 kWh/m^2/year. The excess thermal energy by the HCPV FAE system can be used in order to produce distilled water for various functions of the houses.

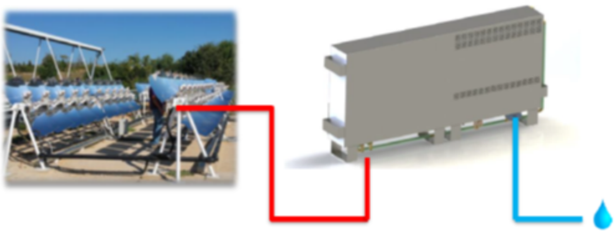


Figure 27. Combination of both systems: FAE HCPV for electrical energy, which is used for HVAC Freescoo

Table 8 shows an overview of the technologies used in the Cyprus case study.

Table 8. Overview of used technologies, their function and expected performance

Case study: Peyia, Cyprus				
Technology	Installation location	Function	Performance	Number of units
FIBRAN	Building	Energy conservation	wall: 3.04 kWh/m^2/year roof: 3.77 kWh/m^2/year	40 mm external walls 80 mm roof
HVAC Freescoo	Building	Energy conservation	29.64 kWh/m^2/year	2 units (1 per villa)
FAE HCPV	Settlement level	Energy production	electrical energy: 9171.41 kWh/year; thermal energy: 12070.84 kWh/year	5 units

Implementation of the technologies selected for the Cyprus case study

HVAC Freescoo system

Freescoo is a plug and play compact HVAC solution fed by low grade thermal energy (solar thermal, HP, gas boiler or waste heat), providing room comfort with cooling, dehumidification, heating, heat recovery and ventilation. It is designed for ventilation, cooling, dehumidification and heating of buildings in the residential and tertiary sectors.

The energy input comes from a water heat distribution loop that can be connected to a solar thermal plant or a gas boiler as back-up energy source. The supply air is sent directly to the conditioned room, but air exchange with an outdoor space is also required.

In the ZERO-PLUS project, the system design has been completely revised to form a compact unit, which can be integrated into the building façade. In total, there are two units of Freescoo system that will be installed in the Cyprus case study on the ground floor of each villa, see Figure 28. The characteristics of the Freescoo system are shown in Table 9.

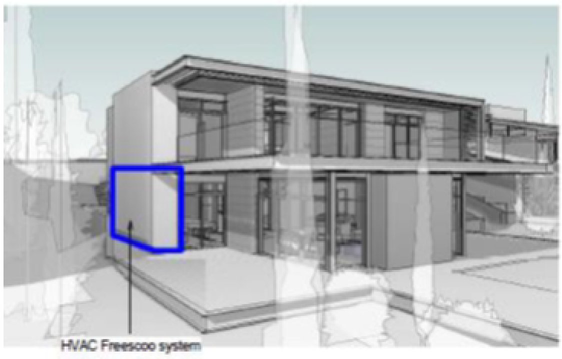


Figure 28. Freescoo system assembly location

Table 9. Characteristics of the Freescoo system

Characteristics	Remarks	
Dimensions	2000 mm x 1000 mm x 350 mm (both units: evaporative and absorption unit)	
Weight	Ca. 130 kg	
Kind of installation	Wall mounted	
Hot water	Two pipes of 1/2" for supply and return	Adsorption unit directly connected to the circuit of solar hot water; a boiler can be used as a backup system;
Cold water	Two pipes of 1/2" for evaporative unit and drain	Evaporative unit directly connected to water supply
Electrical characteristics	220V AC or 24V DC	

For the installation purpose, the Freescoo HVAC system will be equipped with a frame designed with features, such as using minimum parts, flexible, interchangeable, and upgradable, lightweight, and suitable for mass production. In total, three types of frame have been proposed within the project. All frames are made of structural steel profiles and are fixed to the Freescoo system. For ventilation purposes, the external vent cover is designed to bridge up the connection between the external environment and the inlet/outlet air grills of the adsorption bed. The internal vent grill cover consists of two parts, an upper section and bottom section. The upper section provides an adjustable vent grill cover for interior use. The bottom section has two openings that provide easy accessibility during installation of the pipes and during later maintenance, see Figure 29.

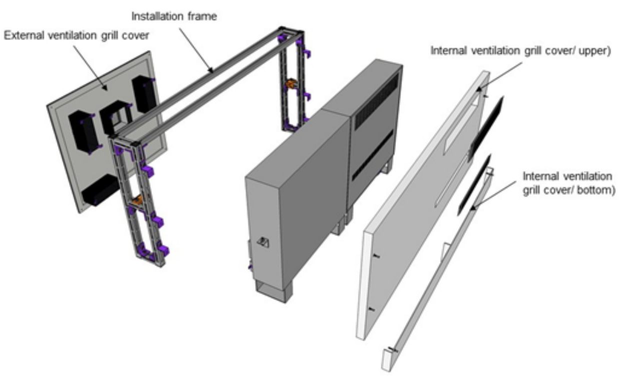


Figure 29. Freescoo system installation frame details

The structural details of the building, the connection methods, the accessibility of the site, etc. must all be considered prior to final installation. The main installation tasks include uploading the system off the truck, hoisting the system and lowering it down to the assembly floor level, transporting the system into the villa, preparing the wall fixing brackets, connecting the system with the fixing brackets, connecting pipes and other appliances, installing external and interior ventilation grill covers, see Figure 30.

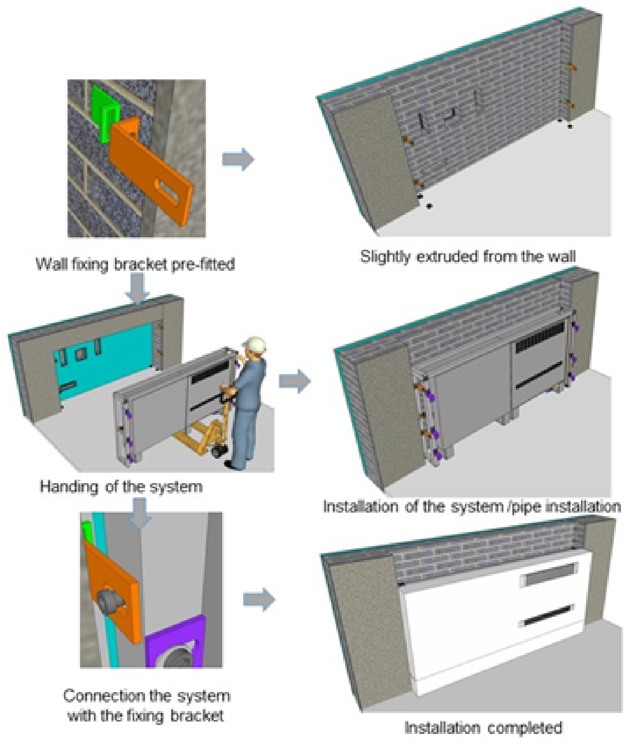


Figure 30. Freescoo system installation method

In the Cyprus case study, the frame and the Freescoo HVAC technology product are half-embedded into the wall. The advantage of this method is ease of assembly and maintenance. Once the ventilation grill cover is removed, the system becomes very easily assessable, see Figure 31.

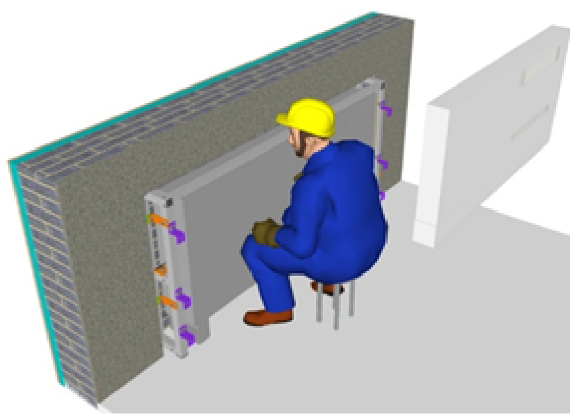


Figure 31. Maintenance of the Freescoo system

FAE HCPV system

The FAE HCPV system exploits the property of optics (lenses or curved mirrors) to focus a wide area impacted by the sun radiation on a small area occupied by one or more high efficiency photovoltaic cells (up to 44% of conversion rate) to generate electricity, see Figure 32. The charateristics of this system are summarized in Table 10. In the Cyprus case study, there will be 5 units of the FAE HCPV system installed at the roof level of the villa, where away from overshadowing from the neighbouring property, see Figure 33. The complex system requires some specific considerations for the installation, such as:

- The height of the supporting foot might be reduced to avoid unpleasant visual impact;
- Special qualified engineers are required to assemble and install the technologies, following instructions from the technology providers.
- The potential installer need to be trained by the technology providers (condition in tender);
- Importance of collaboration with the Main Contractor;
- Proper maintenance from qualified people during the lifetime of the technologies.

Prior the final installation of the FAE HCPV system, the roof of the case study building will be prepared. Afterwards, the final assembly steps will be performed according to the instruction provided by ARCA. Briefly, the individual installation steps are: positioning the center foot and installing the worm reduction gears; installing the side feet and the external axes; installing further components such as the optic port, the transmission system, the actuation system, the optical oncentrator, the heat sink, the hydraulic mounting connectors, the fitting sinks, the rotary encoder.

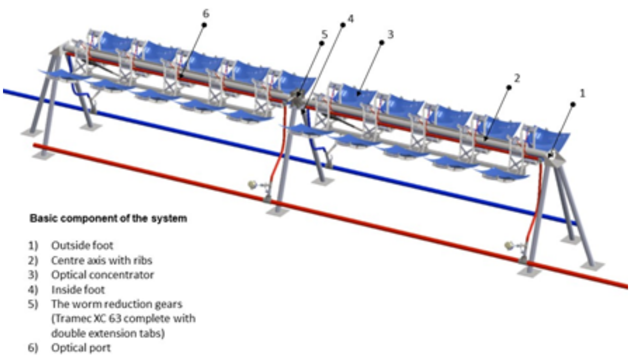


Figure 32. FAE HCPV system components

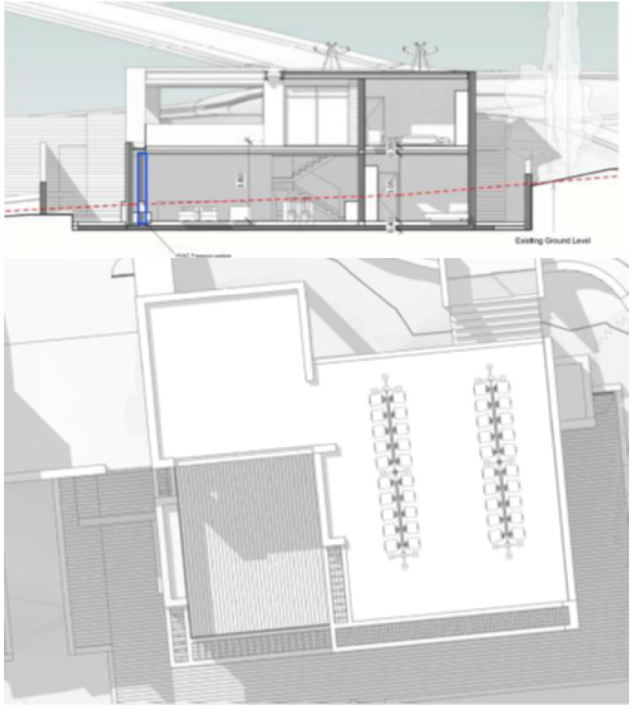


Figure 33. Instalation location of the FAE HCPV system

To ensure the functionality of the system, the mirrors require regular cleaning. The cleaning task need to be done manually and carefully in order not to scratch the mirror surface. The hydraulics and electric connections require regular inspection and maintenance as well. The access for maintenance purpose need to be ensured.

Table 10. Characteristics of the FAE HCPV system

General characteristics of FAE HCPV module	
Net surface of each concentrator	2.025 cm²
Solar concentrator	≈2.000x
Optical efficiency	90%
Tracking system	Two-axis Alt-Alt
Dimension	1.4 x 6.5 m
Weight	280 Kg
Wind resistance	3.4KN/m (wind speed 20m/s)
Heating temperature	60 - 70°C (Compatible with the inlet of the SolarInvent Freescoo cooling units)
Mirrors	Ultraclean glass with silver coating, Reflectivity > 95%
Structure	Galvanized steel

Monitoring and Evaluation of the technology performance

In the case study of Cyprus the FAE HCVP will be installed for energy production on the roof of each villa and HVAC Freescoo for cooling the villas.

The mathematical model, that describes the calculation of energy production as a function of the relevant environmental parameters, was defined for FAE HCPV. The purpose of the model is the prediction of energy production to support maintenance of the technologies. The FAE HCVP mathematical model was created by the manufacturer with inputs date, time, global solar radiation, horizontal solar radiation, ambient temperature, wind speed and outputs the electrical and hot water power. Currently, the link of the prediction models with the Web-GIS platform (see "Design of a monitoring framework for performance assessment during operation") is in progress.

Furthermore, the monitoring equipment for recording and transferring performance data of the energy production technologies to the Web-GIS platform has been developed. A special designed electronic board will be used to gather and transmit the measurements to the Web-GIS platform.

The commercial monitoring equipment that will measure indoor environmental quality and energy consumption of the buildings has been selected according to the specifications that have been set (see "Design of a monitoring framework for performance assessment during operation").

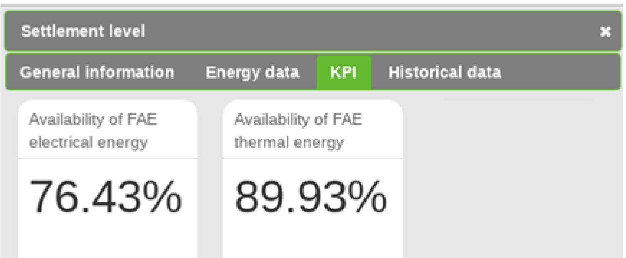


Figure 34. Example screenshot of the KPI's as displayed on the Web-GIS

The specifications have been set by the project's technical committee to ensure the correct measurement of the Net regulated energy (one of the KPIs of the project, see Figure 34), and thermal comfort of the residents of the settlement. The following measurements will be gathered:

- Room temperature, relative humidity, occupancy, illuminance
- Energy for heating, cooling and domestic heat water
- Energy production by RES and consumption by apartment.

The installation, post-installation and post-occupancy measurement and verification procedures for the technologies have been defined in the Measurement and Verification plan of the project. These procedures at installation and post-installation phases coincide with the Commissioning Plan that has been prepared within the ZERO-PLUS project. For the post-occupancy phase, fault detection has been designed and will be incorporated in the Web-GIS platform. Furthermore, reasons of unsatisfactory performance will be detected through a Problem Identification procedure, see Figure 35.

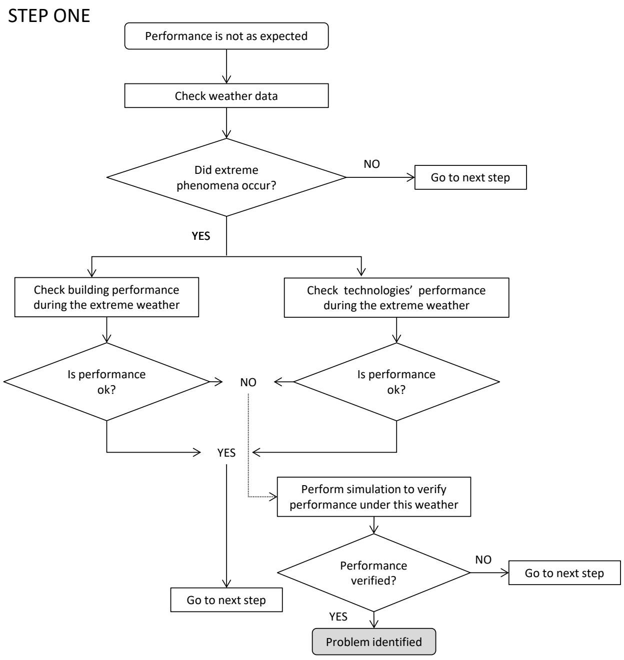


Figure 35. The first step of the problem identification procedure

French Case Study - Voreppe

The town of Voreppe is located in an urban area with a mid housing density in the eastern part of France about 15 km north-west Grenoble city, see Figure 36. Voreppe is a city of 10 000 inhabitants and is located in a lowland between two mountains with a little variable wind direction.

The future building will be erected 200 m away from the railway station linked to Grenoble (10 minutes) as well as the cities located between Voreppe and Lyon.

Figure 36. Location of the Voreppe City

The climate in this area is continental with a temperature gradient that can range from -11°C in winter season and up to + 36°C in summer season. The rainfalls average is around 1000 mm per year.

The ZERO-PLUS building is a collective building with 18 apartments on 4 floors. It includes 7 one-bedrooms, 6 two-bedrooms, 4 three-bedrooms, and 1 four-bedrooms, see Figure 37.

The objectives of the city and OPAC38 are multiple: They focus on the urban development around the railway station settlement. More precisely, two buildings (including the ZERO-PLUS one) of respectively, 18 and about 14 social housing units will be erected and a building of about 20 dwellings for sale will complete this new settlement.

This will foreshadow the future French thermal regulation, the search for savings for tenants and energy autonomy.

Table 11 gives an overview about the main characteristics of the France case study building.

Table 11. Overview of the building parameters for the France case study

General information	**ZERO-PLUS Building**
Total floor area	1 511 m²
Net floor area	1 140 m²
Orientation of the building	South-West
Storeys	4
Bedrooms	-
Thermal transmission coefficients	
U-Values of walls	0.16 W/m² K
U-Values of roof	0.09 W/m² K
U-Values of floor	0.16 W/m² K
Other specific parameters	
Shading	In winter 1 to 2 hours in the morning
Type of glazing	Double glazing

Figure 37. View of the ZERO-PLUS building

Selection process of the technologies used in the France case study

To identify the technologies to implement, a method of Dynamic Thermal Simulation for a calculation of thermal needs for the building was used, except the consideration for the European equipment.

The necessary data and parameters taken into account are:

- The performance of insulators and the glazings (thermal resistance and thickness of insulation)
- The need of the energy systems (electricity consumptions of this equipment, outputs of production of heat, insulating of pipings)
- The surface of the building (surface out of clear work of reference for the thermal regulation)
- The worksheets data of the European equipment manufacturers (outputs of production) to evaluate technologies to be set up.

The urban heating network of Voreppe town is fed by a wood boiler plant with a wood rate and other annual renewable energy higher than 87%, that makes it possible to develop the energy of renewable “district”, see Figure 38.

Figure 38. District heating plant (wood boiler) in Voreppe providing heat to the settlement

Firstly, a heat exchanger of the biomass urban heating network will be used to provide heat (hot water). The heat exchanger is able to deliver approximately 56 000 kWh (heating and hot water) and is connected to the Domestic Hot Water (DHW) tank for the supplement on the production of hot water. The consumption will be reduced via HCPV system developed by IDEA, associated to ARCA Consortium.

For energy storage, a boiler with a capacity of 750 litres for Domestic Hot Water (DHW) - supplement of the HCPV system - will be used, see Figure 39. The building’s DHW boiler, which is connected to the urban heating network and the solar boiler supplied with sensors HCPV, will firstly be powered with the HCPV energy and then completed with the Distric Heating System when needed. The calculation resulted in a thickness of 100 mm for the heat insulator.

Figure 39. Domestic Hot Water tank boiler

The HCPV system developed by IDEA exploits solar radiation to generate electricity and heat at the same time. With the dimensions of 6.4 m length and 1.35 m broad, the HCPV module consists of 10 mirrors distributed on each side of the rotation axis, see Figure 40. Each mirror, with the dimensions of 45 cm x 45 cm, concentrates the sun‘s rays on a receiver composed of an optical glass light tube type BK7 fixed on a triple junction of photovoltaic solar cells. The active surface is 108 mm², with a concentration ratio of about 2000 suns.

Figure 40. HCPV system to be installed on the roof of the France building

For the electricity and heat production in the France case study, 5 solar collectors HCPV will be installed on the rooftop of the France building. The photovoltaic electricity of the HCPV is estimated to provide 5654.27 kWh/year. Furthermore, for the solar production of warm water the HCPV will provide approximately 7875.59 kWh/year (sunning considered: 22 437 kWh/year).

In particular, the HCPV for the photovoltaic part will be connected directly to the inverters of each sensor; electricity is connected to the cupboard of the electric room to the basement and then sold to the French distribution network.

Additional producer of renewable energy in the France case study is the WindRail® C30 module developed by ANERDGY, see Figure 41. The WindRail® C30 represent a modular all in one smart roof edge system, which is flexible in units, energy generation, design options and functions. It combines the key features of energy, design and function:

- *Energy generation*: The innovation of WindRail® C30 is the option to combine wind and sun to produce renewable energy. This is done in combination with the three prevailing energy sources on the building: wind flow, pressure difference between the façade and the building roof, and solar radiation (photovoltaic & photovoltaic with thermal). For PV (photovoltaic) and solar thermal panels WindRail® C30 is using existing standard technology whereas the usage of the wind flow pressure difference was an in-house development by ANERDGY. The technologies as such do exist but the novelty lies in the integration into one system and the positioning at the roof edge.
- *Design*: It is important for architects to be able to integrate the WindRail® C30 modules structurally to the building and get an integrated visualisation concept. The focus on design offers new silhouettes and multiple design options in terms of colouring, illumination or front design. A major aspect is also that with the installation of a WindRail® system other technical installations which are normally built in the inner part of the rooftop can be repositioned under the WindRail® system. This cleans up the rooftop inner area allowing the architect flexibility for alternative uses e.g. greening, urban farming or a terrace.
- *Function*: The WindRail® system comes with a base frame to host the WindRail® C30 modules. This frame together with the WindRail® C30 module integrates building functions such as: lightning protection; safety rail; snow, rain & ice handling, façade water protection and hosting space for technical roof installations.

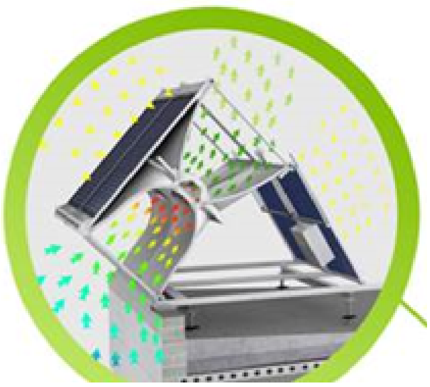
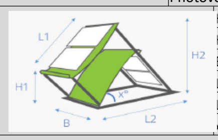


Figure 41. WindRail® C30 used in the France case study

In the French case study, a total of 4 WindRail® C30 modules with the specification according to the information included in Table 12 will be used, see Figure 41. Each module, which is composed of two wind turbines and photovoltaic panels, is positioned at the edge of the terrace roof to take advantage of the outside wind, the heat column effect and the pressure on the building façade giving an additional air flow at the wind turbines. The wind turbines are positioned in a fairing to optimize the energy production.

Table 12. Specifications for the WindRail® C30 module used in France case study

Module		C30-WS+ / 25°
Nominal power (W)	Wind / Pressure	1500
	Photovoltaic	1200
	H_1	1050
	H2	2000
	B	2000
	L1	2600
	L2	4200
	x	25°
Open platform space		4.7 m³
Weight		250 kg
Integrated system safety features:		
- Lightning protection		yes
- Safety rail		yes
- Snow & ice handling		yes
- Rainwater handling		yes

The WindRail® C30 modules are dimensioned for a photovoltaic electrical production of approximately 4130 kWh/year and a wind electrical production of approximately 640 kWh/year. The electricity produced by WindRail® C30 is directly connected to the respective inverter "Photovoltaic WindRail" or „Wind WindRail“ and will be sold to the French distribution network.

In addition to the WindRail® system, solar glass blocks equipped with photovoltaic elements provided by SBskin will be integrated in the west-south façade of a car park. The SBskin´s solar glass blocks cover an area of 12 m² and are part of the apparent basement façade. The dimensions of each solar glass block are 19 cm x 19 cm with a thickness of 8 cm, see Figure 42.

These SBskin´s solar glass blocks are composed of two glass shells with a thickness of 5 mm, one inside and one outside. Between both glass shells, a photovoltaic panel with the thickness of 4.4 to 6 mm integrates the 3rd generation of solar cells sensitized by dye (DSSC: Dye-Sensitized-Solar-Cells).

Both hulls are positioned on either side of a thermal insulation element constituted by a sheet of transparent insulating material with the thickness of 5 mm. Furthermore, both glass shells are assembled together through an insulating profile, whole being welded by a high temperature process for create two cavities 30 mm thick filled with dry air.

The photovoltaic SBskin´s solar glass blocks are gauged for an average photovoltaic energy production of 20 kW/year. The electricity produced by the 12 m² solar glass blocks is connected to an inverter and sold to the French distribution network.

The „wind“ and „photovoltaic“ inverter, which will be installed in the France case study, have the following main characteristics: operating temperature -20°C to 65°C; humidity 4 to 100%, non-condensing; degree of protection IP65; overvoltage protection, electronic control; several electrically separated MPP followers.

Table 13 summarized the technologies used in the France case study.

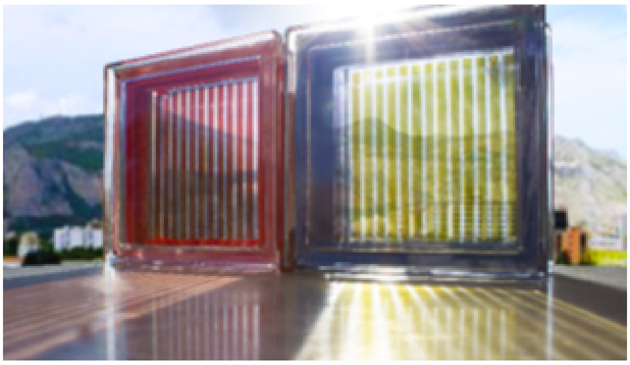


Figure 42. SBskin´s solar glass blocks used in the France case study

Table 13. Overview of used technologies, their function and expected performance

Case study: Voreppe, France				
Technology	**Installation location**	**Function**	**Performance**	**Number of units**
Heat exchanger	Building	Energy production	56,000 kWh	-
HCPV	Building	Energy production	electrical energy: 5654.27 kWh/year; thermal energy: 7875.99 kWh/year (sunning 22,437 kWh/year)	5 units
WindRail® C30	Building	Energy production	Electrical energy: photovoltaic: 4130 kWh/year wind:640 kWh/year	4 modules
SBskin´s glass blocks	Building	Energy production	20 kW/year	12 m²

Implementation of the technologies selected for the France case study

Heat exchanger

The heat exchanger of the urban heating network is located in a sub-station in the basement of the building, see Figure 43.

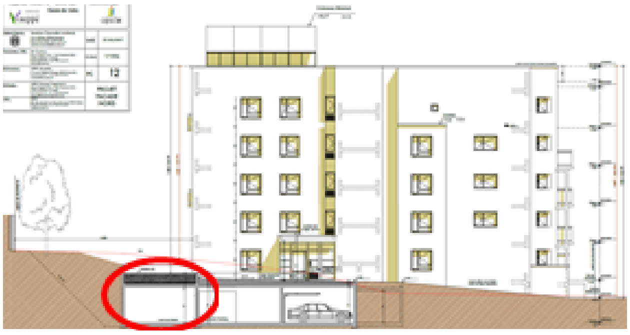


Figure 43. Location place of the district heat exchanger in the France case study building

HCPV system developed by IDEA

The HCPV system developed by IDEA and used to generate electricity and heat with a high combined efficiency will be installed on the roof of the France case study building, see Figure 44.

Figure 44. Location of the HCPV on the roof of the case study building

The assembly technique for the HCPV system in the French case study differs from the assembly procedure described in the Cyprus case study. Here, some larger parts will be preassembled on the ground floor and then hoisted into the correct installation position. The main installation steps, see Figure 45, can be summarized as follows: installing the worm reduction gear on top of the centre foot; installing the external axes on the side feet; installing the optic port and connecting it with the side, centre feet; hoisting the preassembled component up to the correct installation position and connecting the feet to the concrete blocks; installing the transmission, actuation, optical concentrator, and heat sinks and hoisting the preassembled component up to the correct installation position; finally, installing the hydraulic connector, pipes and electrics and the rotary encoder.

The system mirrors require regular cleaning, however, due to the location of the case study, condensation may occur during the evenings that supports a self-cleaning effect to the mirrors. Since the system is located on the roof of a five-storey building, any routine maintenance need to be done by professionals and to comply with the local health and safety regulations.

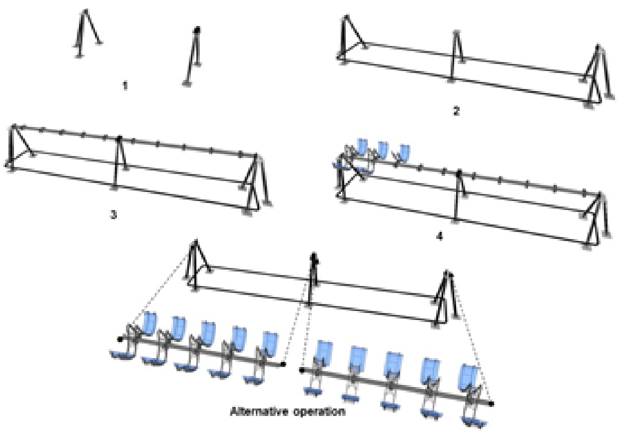


Figure 45. HCPV system installation procedure

WindRail® C30

The combined photovoltaic and wind energy production of the WindRail® C30 will take place on the roof near the edge of the building, see Figure 46. Altogether, four sets of the WindRail® C30 system will be installed on the French case study building. The sets of the WindRail® C-Type system consist of a main frame, a body for energy generation, a base frame, and a base supporting frame. During the ZERO-PLUS project, TUM collaborated with ANERDGY and developed a flexible, adjustable, and feasible base supporting frame system to facilitate the assembly procedure. The proposed base supporting frame system will be used in the French case study for the first time.

Figure 46. Position of the WindRail® C30 on the top of the ZERO-PLUS building

Before the installation of the WindRail® C30 on the edge of the case study building, the structural engineer will ensure the roof is designed structurally sound to support the additional weights. The overall installation procedure, see Figure 47, can be described as follows:

- Measuring and allocating the correct position for the first and the second adjustable supporting leg and positioning them in line with each other.
- Positioning the first main frame on top of the adjusting supporting legs.

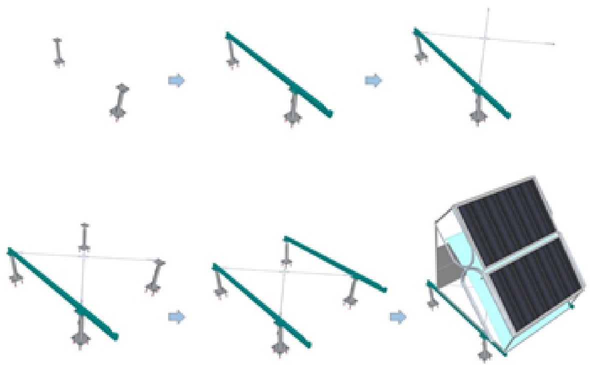


Figure 47. WindRail® C30 installation sequence

- Fastening the connecting nuts, washers and bolts to the correct position and reserve one connection point for the steel cross bracing bar.
- Fastening the steel cross bracing bars on the adjustable supporting legs and in the middle of the system.
- Repeating the previous steps for all adjustable supporting legs until the frame is completed.
- Attaching the WindRail® C30 system with the base supporting frame.
- Installing all electrical devices and connecting them to the grid.

The connection detail of the base frame and the roof of the case study building is composed of a layer of damp proof course to be installed above the concrete roof slab, with a layer of insulation in between, see Figure 48. Finally, a layer of roof gravel is to be placed above the damp proof course. Before installing the base supporting frame, holes are to be drilled in the accurate position and the correct wedge anchor according to the engineer's specification need to be inserted. The construction contractor will advise the specification of the damp proof course product prior to the final assembly.

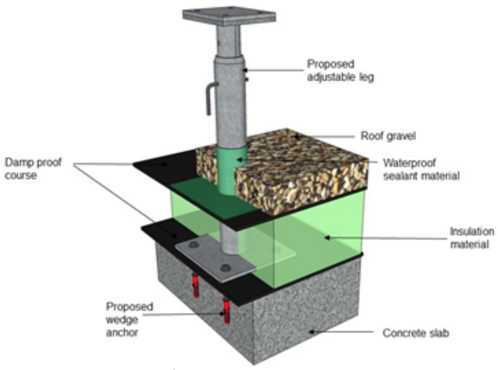


Figure 48. WindRail® C30 installation roof connection detail

The maintenance activities for the WindRail® C30 are minimal and consider mainly the power train: rotors, toothed belt and gears. For this purpose, ANERDGY recommends three types of routine checks, A, C, and D. The A-check will be conducted every year focus on visual inspection of dirt, insects, birds, and cleaning. Also, rotors and textiles have to be checked periodically for damage. The B-check will be performed every 10 years and will place emphasis on the toothed belt, gears, and rotors. In addition, a D-check will take place after 20 years of usage.

When maintenance is required, the WindRail® C30 can be folded and slide back along the base supporting frame, see Figure 49. The lifting mechanism is checked automatically in maintenance mode. Furthermore, many maintenance tasks can be done remotely, as the maintenance contractor has detailed data about the performance of each unit.

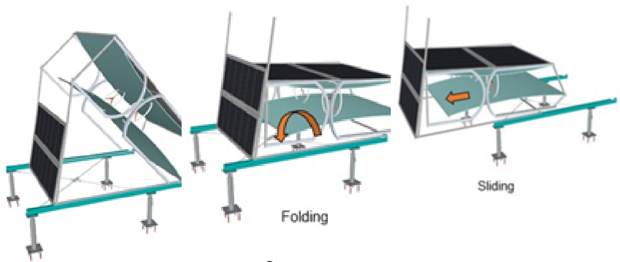


Figure 49. WindRail® C30 maintenance procedure

SBskin´s solar glass blocks

The 12 m² of the SBskin´s solar glass blocks for the energy production will be integrated on the south-west side of the car park façade at the lower section of the building, see Figure 50.

Figure 50. The installation location of the SBskin´s solar glass blocks

The SBskin´s solar glass blocks are assembled through a dry, mortarless system based on plastic profiles, where the electric connections are also integrate, see Figure 51. Furthermore, the supporting structure made of vertical and horizontal plastic profiles offers also space for pre-stressed steel bars connected to a base plate responsible for the mechanical resistance of the system against horizontal actions due to e.g. wind. This solar glass blocks system allows for a reduction in time, cost of installation and to obtain homogeneous glazed surface with only 2 mm joints between the glass blocks. In addition, it can easily be connected to the load-bearing structure of the building through mechanical assembly systems.

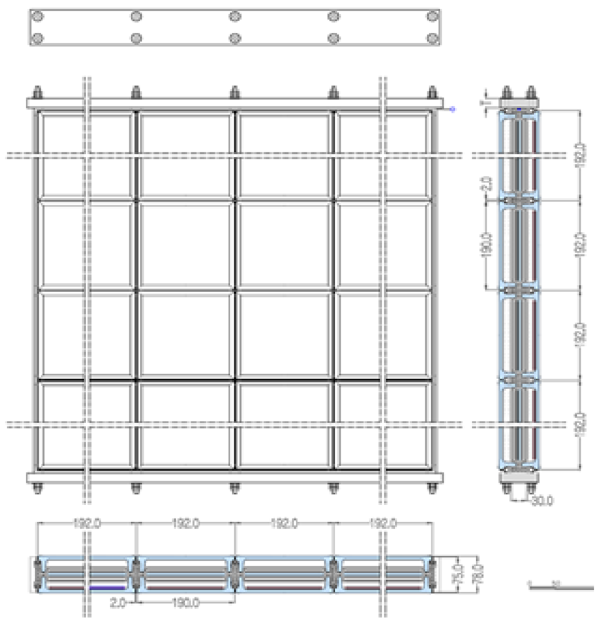


Figure 51. SBskin´s solar glass blocks system

The general installation procedure to the building includes the assembly of four parts, the front and rear seal panel, the solar glass blocks system, and the installation frame, which need to be fixed to the façade wall, see Figure 52. In the first step, the solar glass blocks system will be assembled and the installation panel will be attached to the top and the bottom of the solar glass blocks system. Afterwards, both parts will be installed into the wall using the connection plates fixed on the wall. In the following step, all electrical wiring and power supply will be connected and finally both seal panels will be installed.

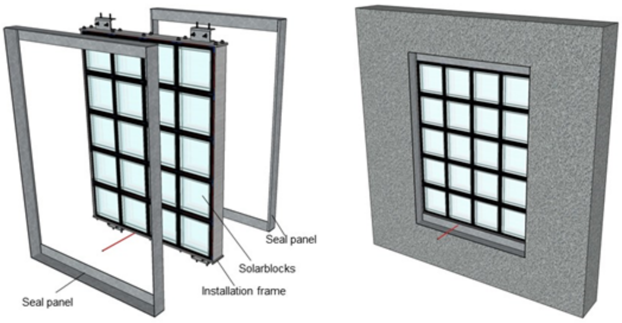


Figure 52. SBskin´s solar glass blocks installation parts and integration into the building wall

For the electrical connection, two wires (+ and -) of 2.5 mm diameter (which could also be grouped into one single terminal element) come out from the panel. Their position can vary according to the needs of the project, e.g., along the edge of the panel, hidden by the framing element.

Different terminal elements can be installed depending on the requirements of the connection between the panel and other electrical equipment. Additionally, a battery and an inverter are required but further information about dimensions and characteristics is needed. In this case, a specific solution can also be configured depending on the needs and characteristics of the electrical design of the building facade.

The integration of solar glass blocks into the gerade façade at the lower section of the building requires regular cleaning of the glass surface to ensure best performace of the technology for the energy production. Furthermore, periodically monitoring of the sealing materials (gaskets and/or silicon) for the possible degradation need to be taken into account. In case, it is necessary to replace the solar glass blocks, thanks to the product feature, they could be taken out of the frame and replaced, or dismantled to replace a single glass block and subsequently remounted.

The installation and maintenance of the innovative-technologies used in the ZERO-PLUS project requires skilled personnel with knowledge about the specifications of the products. OPAC38 and the Project Management worked together to select qualified companies able to assemble the different innovative systems correctly. A specific call for tenders has been drawn up to allow this selection. Companies installing the technologies will have to respect and to follow manufacturer´s information for the installation of each system. The settings will be done jointly with the material suppliers. In addition, a synergy between installers and suppliers will be created by training the first by the second.

Furthermore, OPAC38 is establishing a partnership with INES (National institute of Solar Energy) which will allow to follow-up the installations. This partnership can last one to three years based on a renewable duration. The OPAC38 services were requested and work upstream, mainly with the maintenance service to anticipate the needs.

Maintenance companies are not currently trained to these new technologies. A collaboration with a national administration called „INED“, which is specialized in renewable energy, will help OPAC38 to take this reality into account. Thus, INED will be able to train the companies that will be responsible for the maintenance of these new materials. INED in collaboration with the technology providers will install a maintenance protocol to help the selected companies to set up this phase.

Monitoring and Evaluation of the technology performance

In the case study of France the WindRail® C30, the FAE HCPV as well as the SBskin´s solar glass blocks will be installed for energy production.

The mathematical model, that describes the calculation of energy production as a function of the relevant environmental parameters, was defined for all technologies. The purpose of the models is the prediction of energy production to support maintenance of the technologies. The WindRail® C30 mathematical models were created by the manufacturer and they have two components a wind turbine and PV panels. The wind turbine mathematical model has as input the wind speed and direction, and outputs the electrical power. The PV panel's mathematical model has as input the date, time, global solar radiation and outputs the electrical power. The FAE HCVP mathematical model was created by the manufacturer with inputs date, time, global solar radiation, horizontal solar radiation, ambient temperature, wind speed and outputs the electrical and hot water power. The SBskin´s solar glass blocks´ mathematical model is based on the free library PV_LIB by Sandia National Labs and has as input the specifications of the PV panels, orientation, date, time, global solar radiation, ambient temperature, wind speed and outputs the electrical power. Currently, the link of the prediction models with the Web-GIS platform (see "Design of a monitoring framework for performance assessment during operation") is in progress.

Furthermore, the monitoring equipment for recording and transferring performance data of the energy production technologies to the Web-GIS platform has been selected. The inverter that will be used to connect WindRail® C30, the FAE HCPV and the SBskin´s solar glass blocks to the French national energy grid will be used to measure the power and energy production.

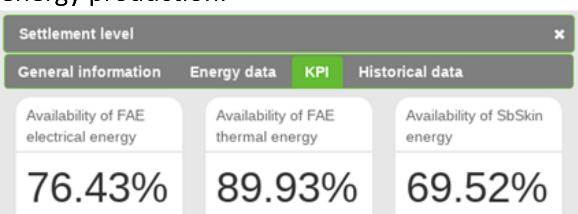


Figure 53. Example screenshot of the KPI's as displayed on the Web-GIS

The commercial monitoring equipment that will measure indoor environmental quality and energy consumption of the buildings has been selected according to the specifications that have been set (see "Design of a monitoring framework for performance assessment during operation"). The specifications have been set by the project's technical committee to ensure the correct measurement of the Net regulated energy (one of the KPIs of the project, see Figure 53), and thermal comfort of the residents of the settlement. The following measurements will be gathered:

- Room temperature, relative humidity, occupancy, illuminance
- Energy for heating, cooling and domestic heat water
- Energy production by RES and consumption by apartment.

The installation, post-installation and post-occupancy measurement and verification procedures for the technologies have been defined in the Measurement and Verification plan of the project. These procedures at installation and post-installation phases coincide with the Commissioning Plan that has been prepared within the ZERO-PLUS project. For the post-occupancy phase, fault detection has been designed and will be incorporated in the Web-GIS platform. Furthermore, reasons of unsatisfactory performance will be detected through a Problem Identification procedure, see Figure 54.

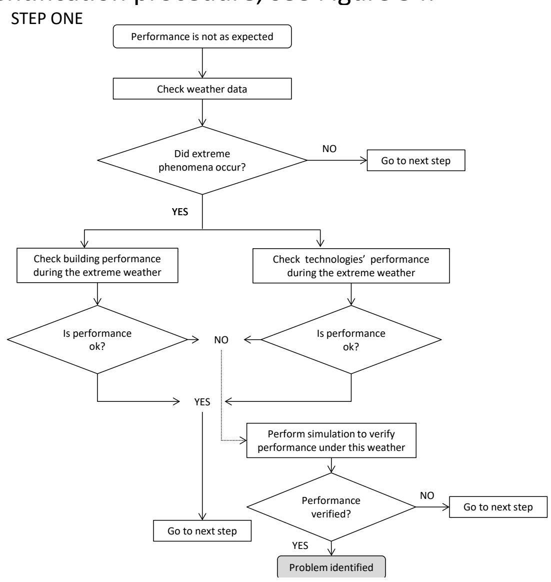


Figure 54. The first step of the problem identification procedure

The business case and market potential for ZERO-PLUS settlements

In the last year, ZERO-PLUS has reached two important milestones on the way to achieving business growth for the products and technologies used in the project.

The first milestone was the analysis of the business case for the ZERO-PLUS concept (see "Analysis of the business case for the application of the technologies and processes developed in the project"). The analysis started by working out the main aims of the business case. This was done by examining the nature of the project, assessing the strategic landscape and building the case for change. First, the nature of the project was examined by comparing traditional construction methodologies and the ZERO-PLUS approach, see Figure 55, to understand the particularities of the latter.

The most important benefits the project wants to achieve were identified as being:

- Social progress and reduced environmental impacts of buildings
- Cost reduction of energy-efficient settlements
- Increased innovation capacity in the construction sector
- Integration of the construction supply chain
- Harmonisation of national implementation of energy efficient construction.

Other approaches used to identify the main aims of the business case were the analysis of KPIs in the construction sector, the methodologies of other EU projects, the barriers and constraints of the ZERO-PLUS concept in achieving its goals, and a stakeholder analysis including potential competitors. To complete this part of the business case, an Exploitation Strategy Seminar was held at the ZERO-PLUS 3rd Progress Meeting in Palermo, Italy in March 2017.

The analysis led to eight options being identified for developing the business case. Based on an estimate of the fit of each option with the nature of the ZERO-PLUS project, the case for change and the strategic landscape, four options were selected for further analysis: developing a settlement efficiency standard, setting up a joint venture for providing construction-related services, developing a settlement passport or a ZERO-PLUS toolkit. These were then ranked according to their achievability (assessed by looking at risks and implementation time) and attractiveness (defined as benefits vs. costs).

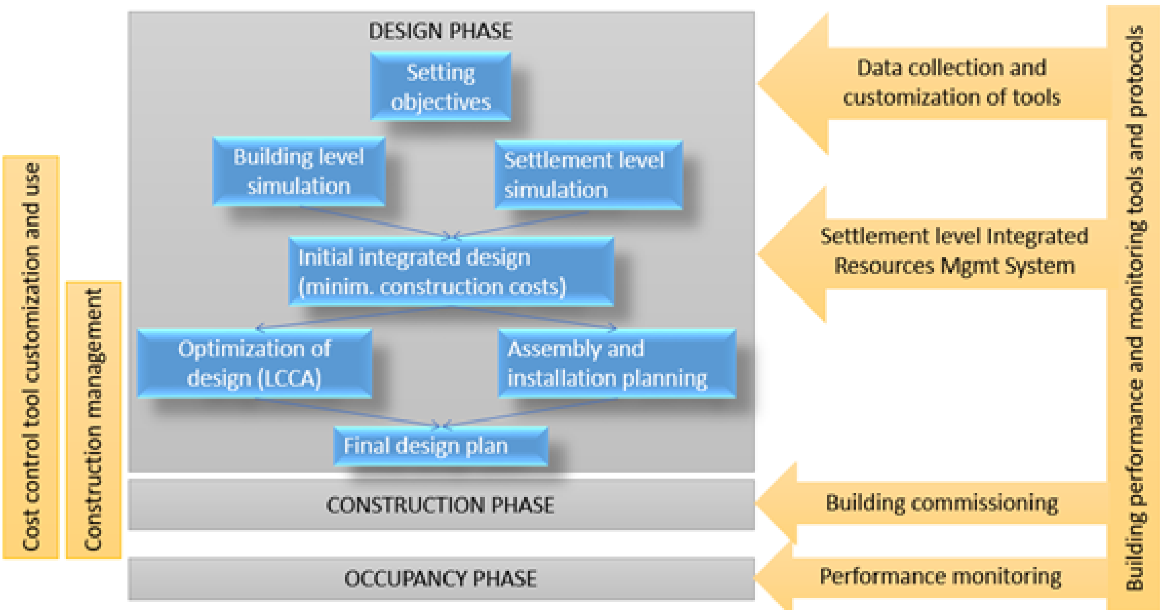


Figure 55. ZERO-PLUS approach to construction

The second milestone was achieved after analysing the market potential within the EU28 for near zero-energy buildings constructed using the concepts developed in the project (see “Analysis of the market potential within the EU28 for “nearly zero-energy” buildings constructed using the concepts developed in the project“). Three approaches were used to determining market potential: a top-down, demand-side and supply-side approach. In addition, procurement in the construction industry was reviewed, including types of procurement, the methods of supplier selection, transaction costs and innovation in procurement.

In the top-down approach to assessing market potential the relationship between GDP and the size of the construction market is used to estimate the market size for settlements based on expert insight. These calculations resulted in an estimate of 1.9% of GDP accounted for by new residential construction output in 2020. Based on this figure, it was estimated that for the EU-28 plus Switzerland and Norway, the total size of the new residential construction market will be around 320 billion Euros in 2020. Currently, approximately 20% of the residential construction market consists of settlement construction, leading to an estimated figure of 64 billion Euros in the EU-28 plus Switzerland and Norway in 2020 going to the construction of settlements.

The demand-side approach assesses the expected demand for new residential construction. The demand for housing can be seen as a function of population growth, household-size development, available income, and the situation of new consumers entering the market, such as migrants and younger generations still living with their parents.

It is estimated that in total, more than 14 million new homes will be needed by 2040 in the EU as a whole. If the ZERO-PLUS approach is used instead of the reference approach for near zero energy construction, the possible total savings until 2040 could reach more than 70 billion Euros.

Assuming that that roughly 20% of new homes will be constructed in settlements, about 3 million dwellings can be expected to be constructed in settlements in this period.

At this point it is important to acknowledge that while ZERO-PLUS addresses Europe only, in keeping with the nature of the ZERO-PLUS project, population growth and the resulting need for new housing outside Europe will be far greater in the coming decades. At the global level therefore, the market for new technologies in residential construction will be concentrated in areas outside Europe.

The supply-side approach considered the evolution of the building permits issued in selected countries as well as the evolution of construction costs, the dwelling stock and a short analysis of companies in the construction industry. Recent developments of these parameters all indicate that the construction industry in Europe is slowly recovering from the economic crisis, meaning that in the coming years there should be increasing room for investing in innovations in the sector.

Concerning procurement, one of the main barriers to the market uptake of technologies for near zero-energy buildings is that their effective development requires non-standard procurement practices. A high degree of collaboration is required, and in the construction industry collaborative practices are an exception rather than the norm in most countries. However, in recent years collaborative approaches towards procurement in the construction industry have been becoming more common. Energy performance contracts provide a good example of how incentives can work towards achieving energy targets, while implementing collaborative techniques.

Summing up, both the top-down and the demand-side approaches for estimating the market potential indicate that there is a large potential market for ZERO-PLUS settlements in Europe. However, the analysis of procurement practices shows that there are also significant challenges to be overcome if this potential is to be realised.

Dissemination

The success of the ZERO-PLUS project depends on outstanding project results, on-site work execution as well as on the dissemination, communication and exploitation of the generated knowledge to the broad public and specific professional target groups from industry, planners, politicians, funding institutions, academics, etc.

In the second period of the project (1^{st} of October 2016 – 30^{th} of September 2017) many different dissemination activities have been performed by the project consortium. Apart from the continuously updating the miltilingual project website with the latest activities, news and outputs of the project to keep the visitors informed, the project partners also attended conferences, published papers and a booklet about the latest achievement within the project has been released.

As soon as new input and material are available, the news, newsletters (e.g. newsletter #4 and #5), activities, and outputs sections are readily updated on the ZERO-PLUS website. The content on the website is available in English and most of them is also translated into French, Italian and Greek. In addition, the project website has been extended by new interesting categories, such as e.g. Interviews, Booklet and Publications.

The new category "Interviews" located under the navigation button "News" includes video or radio interviews given by the project partners at different channels (5 interviews). These interviews are embedded into the web page and available for watching.

The results achieved by the project consortium within the first project period - 1st of October 2015 to 30th of September 2016 – are sumarized in the first booklet. The booklet introduces brieftly the four case studies (France, UK, Italy, and Cyprus) and the ZERO-PLUS technologies (SBskin, HCPV, Solarinvent Freescoo, FIBRAN, WindRail®, and ABB) and provides an overview of the outcomes of the project. The first issue of the booklet can be downloaded by "Booklet" under the navigation bar "Outputs". All further booklets will be archived here as well.

The latest updates of the ZERO-PLUS website relate to the integration of videos and picture slide shows representing the Case Studies or/and Technologies. In particular for the case studies, a new item "Video" was created and liked to the architecture visualization videos of the respective case study buildings. In addition, under the item "Live View" the first picture slide show, in particular for the Italian case study, shows the construction process on site. Furthermore, an installation video for the LFR technology is embedded on the ZERO-PLUS website.

Other innovation on the ZERO-PLUS website is the new category "ABB Smart Lab" under the navigation bar "Technologies". Here, a brief introduction and a video provided by the ABB partner inform the visitors about the function of the lab.

The outcomes of the projects achieved by the consortium have been also documented in the various project reports (11 project reports for public purpose), presented at different national and international conferences or/and workshops (18 conferences and 12 workshops, seminars and events until end of September 2017) and published in diverse scientific papers, articles and press releases (8 scientific publications, 13 articles, and 2 printed interviews until end September 2017). All project reports released for public are archived for download on the ZERO-PLUS website under the navigation bar "Outputs". The scientific publications are available on Open Air and furthermore, also listed and uploaded on the ZERO-PLUS website unter the new created category "Publications" under the navigation bar "Outputs".

The project activities of the consortium as well as the latest outcomes are also communicated and disseminated through the ZERO-PLUS social media accounts Twitter and Facebook. By the end of September 2017, about 64 Tweets and 46 articles on Facebook were distributed through the social media channels. Please follow us on our social media accounts to get the latest news and outcomes of the ZERO-PLUS project.

Find us on Facebook | Follow us on twitter

This project has received funding from European Union´s Horizon 2020 research and innovation program under grant agreement No. 678407.

Impressum

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Reporting Period:
1st of October 2016 - 30th of September 2017.

Released on:
March 2018

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