H2020 – NMBP – EEB – 2019 – GA 869898

Highly advanced modular integration of insulation, energising and storage systems for non-residential buildings

D8.1 DESCRIPTION OF PILOT SITES AND BOUNDARY CONDITIONS

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Reviewed and approved by	Consortium steering committee	22.01.2021

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 869898

Distribution list

External		Partner short name	
European Commission	1x	Consortium partners	1x
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Change log

Issue	Date	Pages	Remark / changes	Pages
V0.1	30.10.2020	-	First document draft by Zdenko Malík (CVUT)	Section 1 and 5
V0.2	28.12.2020	All	Second document draft by Zdenko Malík (CVUT)	All
V0.3	31.10.2020	All	Third draft by Zdenko Malík (CVUT) and reviewed by Jorge Corker (IPN)	All
V1.0	22.01.2021	All	Submitted report reviewed by all partners	All
V2.0	16.07.2021	All	Included the acknowledge of funding and disclaimer	1, 2

To be cited as

CVUT (2021): "D8.1 – Description of pilot sites and boundary conditions" of the HORIZON 2020 project POWERSKIN+. EC Grant Agreement No. 869898, Prague, Czech Republic.

Disclaimer

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1. Summary

Deliverable D8.1 "*Description of pilot sites and boundary conditions*" presents POWERSKIN+ pilot sites' initial description. At these sites, pilots/demos of the POWERSKIN+ system will be installed, monitored and assessed. The description focuses on the pilot sites locations, climate as well as on the construction, building systems and usage of the buildings for the pilots/demos installation. It presents the information which the consortium has been able to gather and document. The whole duration of Task 8.1 has been affected by the ongoing COVID-19 pandemics, which has restricted travel and complicated the data acquisition. The document also lists the sensors to be used for the baseline monitoring of the pilot sites.

2. Introduction

This document aims to report on the state of the pilot sites in terms of location, construction and POWERSKIN+ demo installation plans. While each pilot kit's detailed form will be determined based on the outcomes of still ongoing work packages, the integration possibilities are described to the currently available level of detail.

The whole duration of Task 8.1 (the base work for this document) has been affected by the ongoing COVID-19 pandemics, which has restricted travel and complicated the data acquisition.

The presented document describes the conditions at the IPN demo site in Coimbra, Portugal (PT), which will be integrated into an office building built in 2007, the CVUT demo site in Buštěhrad, Czech Republic (CZE), which will be integrated into a multi-use university research building, and two alternatives to the originally proposed school building demo site in Radovljica, Slovenia (SL). These alternatives are put in place as a mitigation action invoked by the inability to secure the required contracts with the school building's owner. The proposed alternatives are buildings owned by the consortium members, eliminating the need for negotiations with external building owners. These buildings are parts of factory parks, including office areas and meeting rooms.

The described baseline monitoring equipment is being tendered at the time of submission of this report. It describes the main characteristics of the sensors to be used for three demo sites.

3. Demo IPN

3.1 Demo location

The POWERSKIN+ demo installation location is a building in the IPN Incubadora campus located in the city of Coimbra, Portugal. The city of Coimbra is well connected to Lisbon (197 km) and Porto (116 km), by railway and by the IC2, IP3 and A1 motorways making it also accessible by plane through both cities' airports.

The terrain slowly rises in the eastern direction from the city towards the mountainous, covering the Beiras region and the Serra da Estrela. In the western direction, the terrain is flat with a smooth slope towards the Atlantic Ocean.

The IPN Incubadora building is well positioned near the main city roads guaranteeing easy access for construction phases.

FIGURE 1: LOCATION OF THE CITY OF COIMBRA AT A LARGER SCALE[1]

[1] 'Google Maps', Google Maps, accessed 20 May 2020, https://www.google.com/maps/@41.4715335,-1.5103594,5.54z?hl=en.

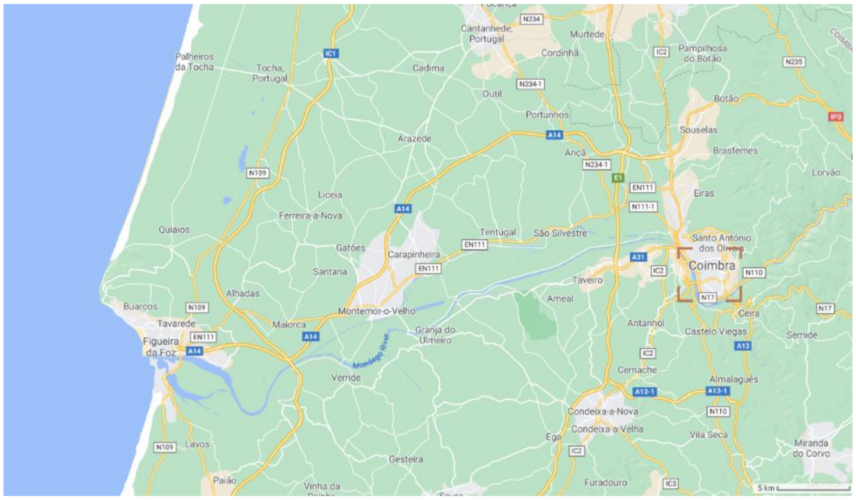


FIGURE 2: LOCATION OF THE CITY OF COIMBRA AT MEDIUM SCALE[2]

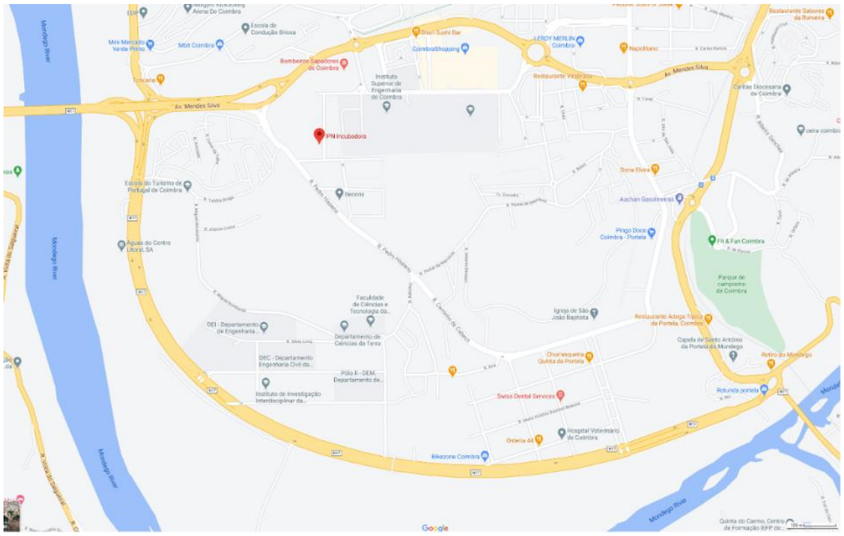


FIGURE 3: LOCATION OF DEMO SITE WITHIN THE CITY OF COIMBRA[3]

3.2 Climate analysis of the demo location

There are several statistical weather files available for the demo location. Through the EnergyPlus website[4], it is possible to obtain the IWEC weather file developed in 2001. The period of record cited in the file is 1973-1995. Considering the current climate change conditions, these data may be seen as outdated for precise simulations.

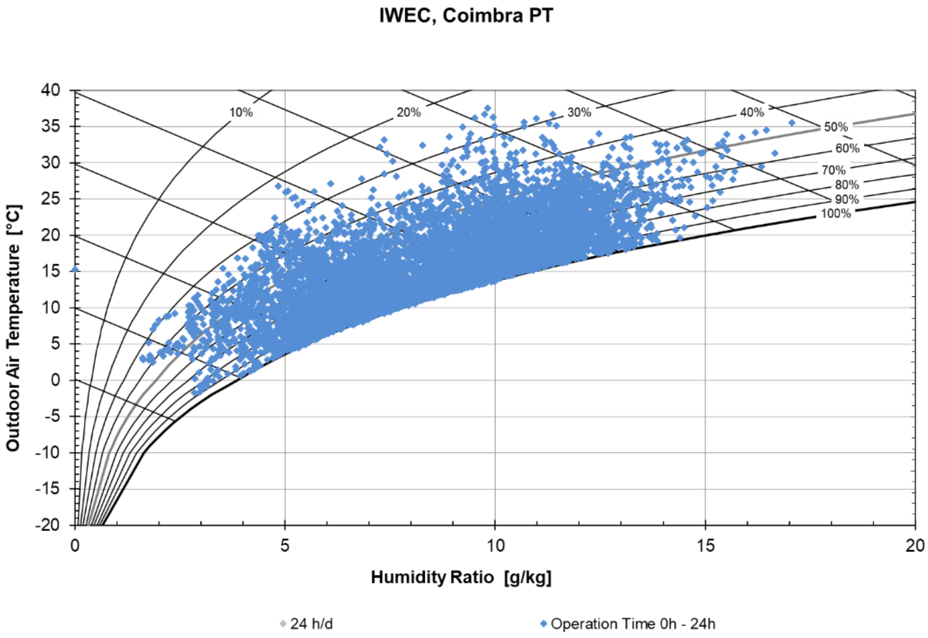
[2] 'Google Maps', Google Maps, accessed 20 May 2020, https://www.google.com/maps/@40.1761814,-8.5282178,10.63z?hl=en.
[3] 'Google Maps', Google Maps, accessed 20 May 2020, https://www.google.com/maps/@40.1888235,-8.4088214,16.31z?hl=en.
[4] 'Weather Data | EnergyPlus', accessed 14 March 2020, https://energyplus.net/weather.

A more recent weather file in the TMYx format has been created by Dru Crawley and Linda Lawrie from climate.onebuilding.org[5]. Their weather files provide a typical meteorological year considering the meteorological data recorded between 2004 and 2018. Both files use the data reported from the WMO meteorological station # 085490 located near the pilot site in Coimbra.

Figures below compare these two existing weather files. The information most relevant to the POWERSKIN+ installation and operation are the relation between the air temperature and humidity (shown in an HX-Diagram), air temperature itself and global solar irradiation.

The HX-Diagrams (Figure 4) show hourly data from the above-mentioned weather files and combine air temperature and absolute/relative humidity information. When a building is ventilated with outside air, components with low surface temperatures (e.g., active glazing used for cooling) may be exposed to the risk of water vapour condensation on their cold surfaces. Within the POWERSKIN+ project, the HX-Diagram can be used to identify the potential for cooling without the risk of condensation. When comparing the HX-Diagrams for both weather files, it appears that the climate in Coimbra is slightly warmer than it used to be. Interestingly, the new climatic data derived from recorded measurements in 2004-2018 do not contain any sub-zero temperatures of the outside air as opposed to the older IWEC weather file. This has been further supported by the actual measured air temperatures in the location in the past three years: 2017, 2018 and 2019, available at the US National Oceanic and Atmospheric Administration, i.e., the database from which the IWEC and TMYx weather files were derived. The data also suggest that the increased air temperature is accompanied by the change of the absolute and therefore relative air humidity. This may have been caused by the change of prevailing winds, which according to the wind roses shown in Figure 5 are not blowing from the ocean in the recent years, and second, by the increased solar irradiation shown in Figure 6. Therefore, the overall climate is slightly dryer. Relative humidity in cold temperatures is still high, whereas the summers are rather dry.

[5] Linda K Lawrie and Drew Crawley, 'Development of Global Typical Meteorological Years (TMYx)', n.d., http://climate.onebuilding.org.



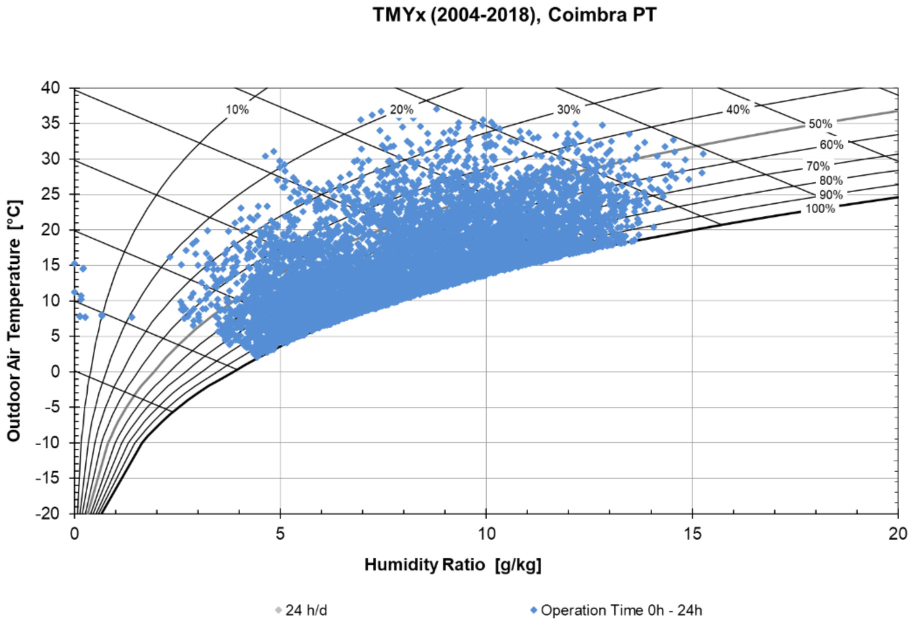


FIGURE 4: COMPARISON OF THE TWO EXISTING WEATHER FILES FOR COIMBRA (PT): THE AIR TEMPERATURE AND HUMIDITY RELATION

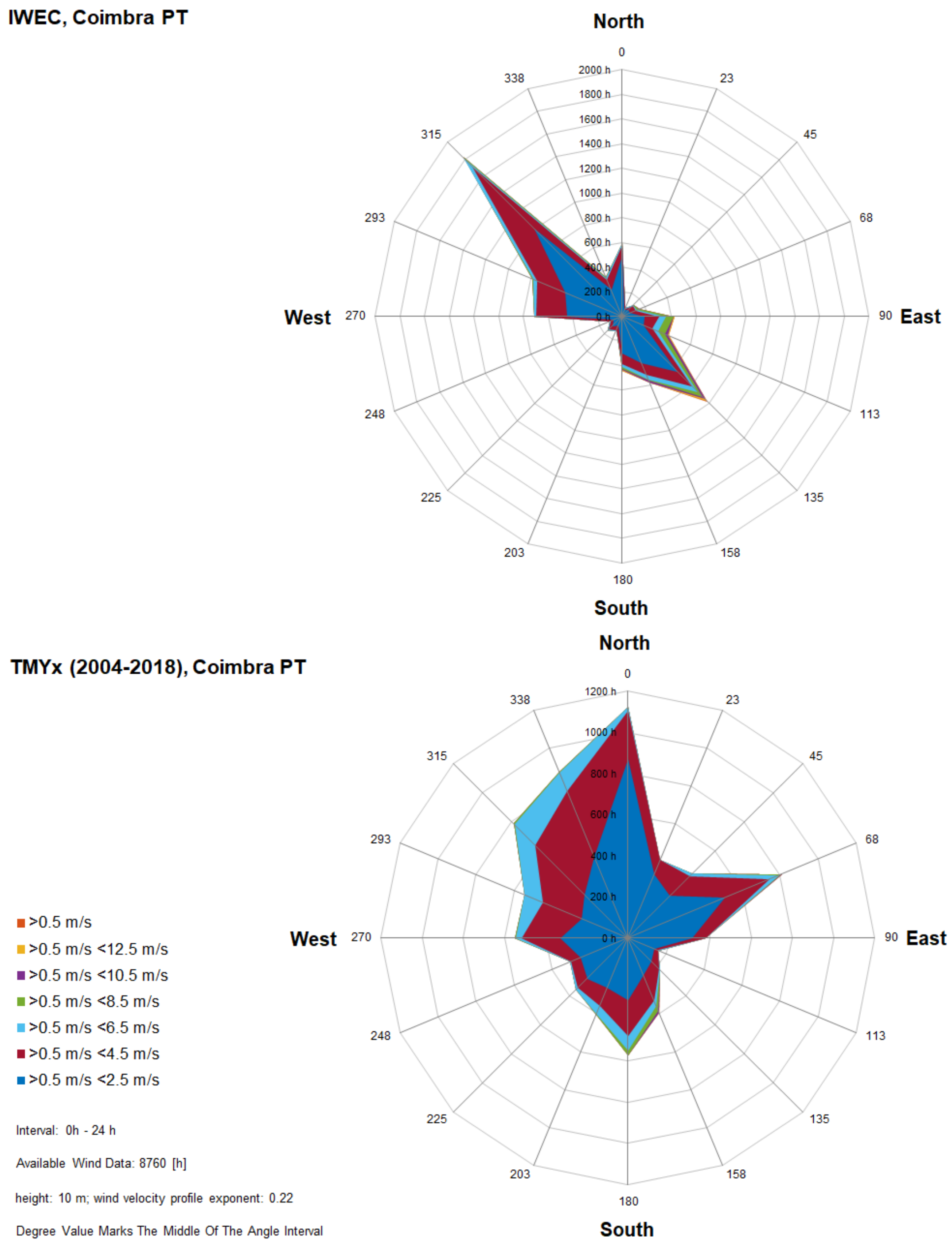
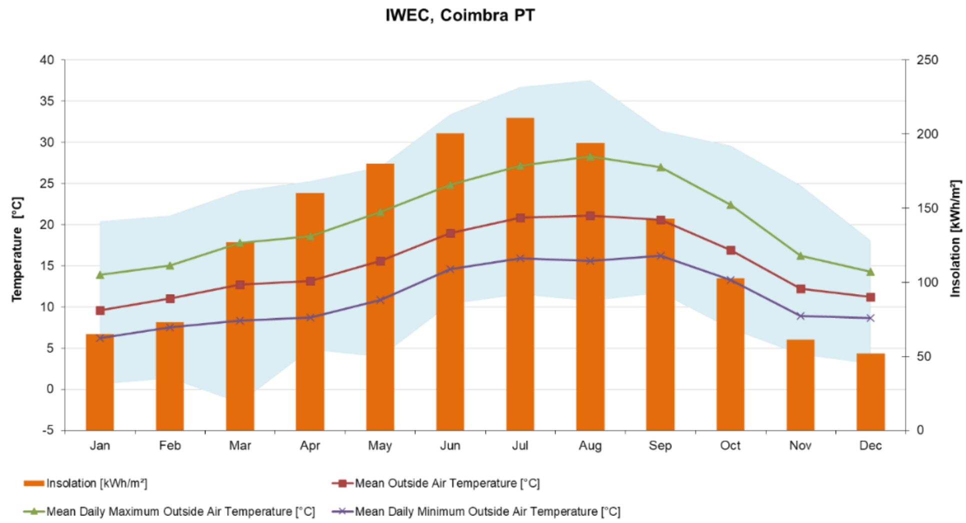


FIGURE 5: COMPARISON OF THE TWO EXISTING WEATHER FILES FOR COIMBRA (PT): THE WIND SPEED AND DIRECTION



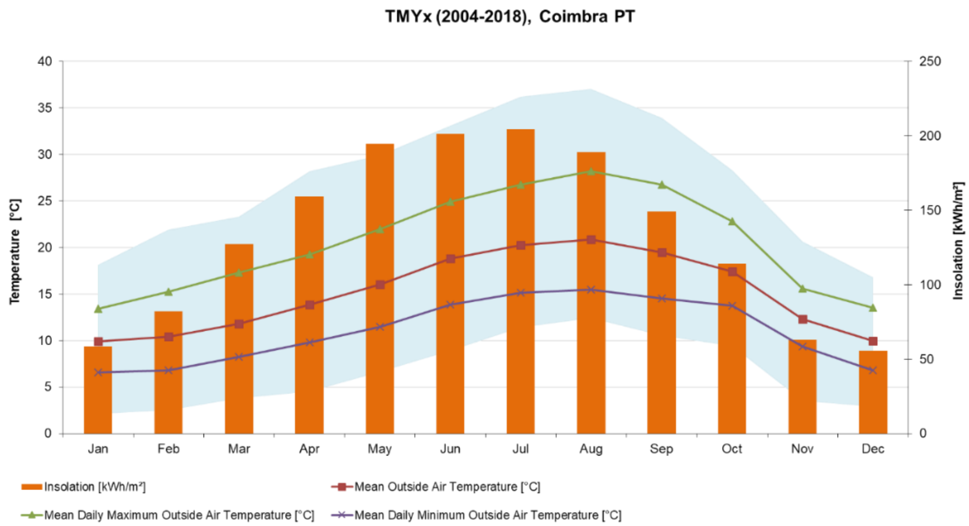


FIGURE 6: COMPARISON OF THE TWO EXISTING WEATHER FILES FOR COIMBRA (PT): THE AIR TEMPERATURE AND GLOBAL SOLAR IRRADIATION ON A HORIZONTAL PLANE

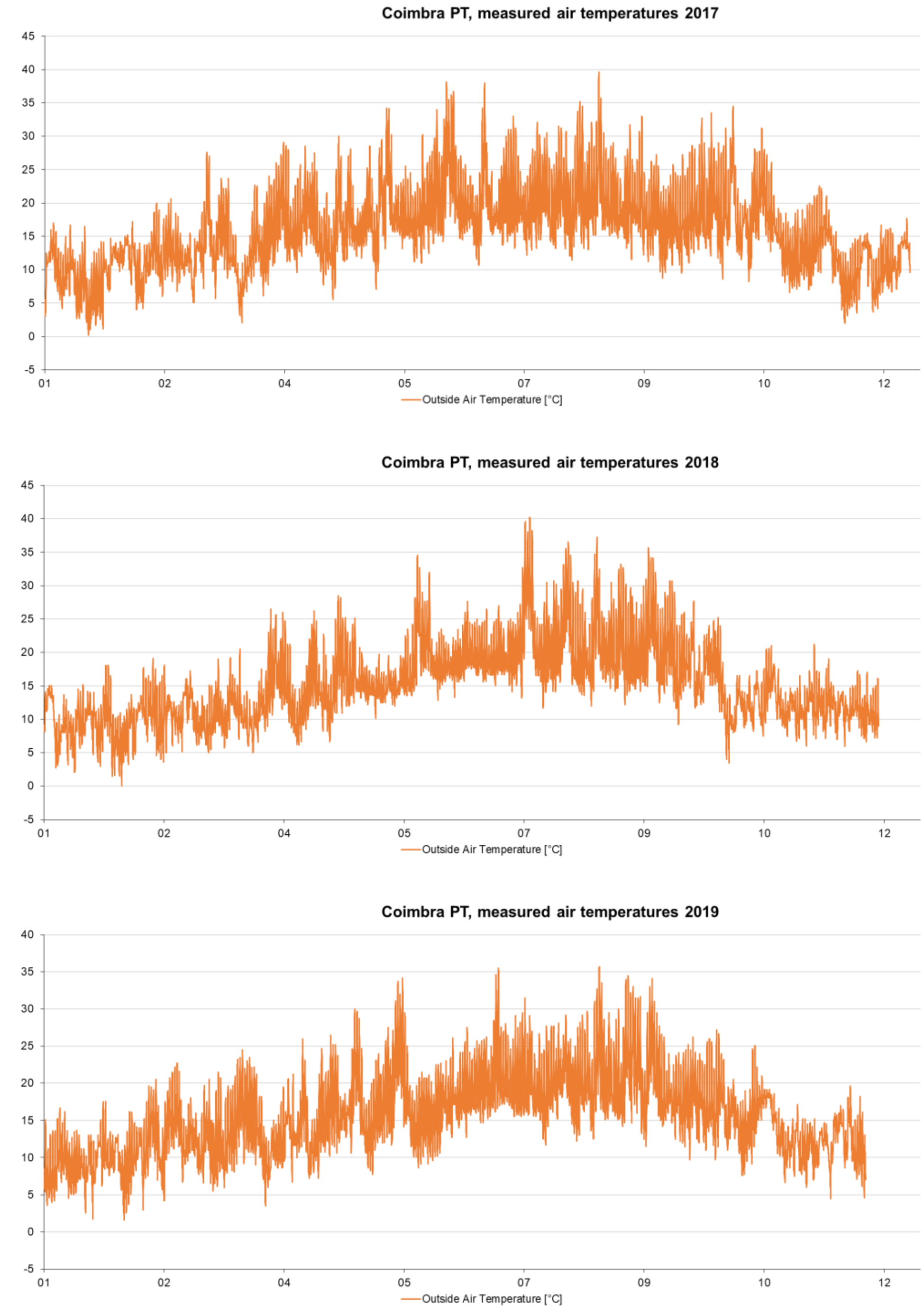


FIGURE 7: MEASURED AIR TEMPERATURES IN COIMBRA (PT) IN 2017-2019[6]

[6] 'Data Access | National Centers for Environmental Information (NCEI)', accessed 3 April 2020, https://www.ncei.noaa.gov/access/search/data-search/global-hourly?stations=08548099999&startDate=2016-01-01T00:00:00&endDate=2016-12-31T23:59:59&dataTypes=TMP.

3.3 Demo building description

3.3.1 General description

The IPN Incubadora building was built in 2007. It has an L-shaped floorplan and consists of two above-ground floors and one partly underground floor. The main facades of the building are oriented to the four cardinal directions.

The building is used as an incubator of many micro and SME companies, and it contains offices, meeting rooms, lecture halls and a cafeteria. It is mostly occupied during the workdays, with minimal occupancy at the weekends.

The surrounding area corresponds with the terrain category III (i.e., an area with a regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights - such as villages, suburban terrain, permanent forest) according to the Eurocode 1.

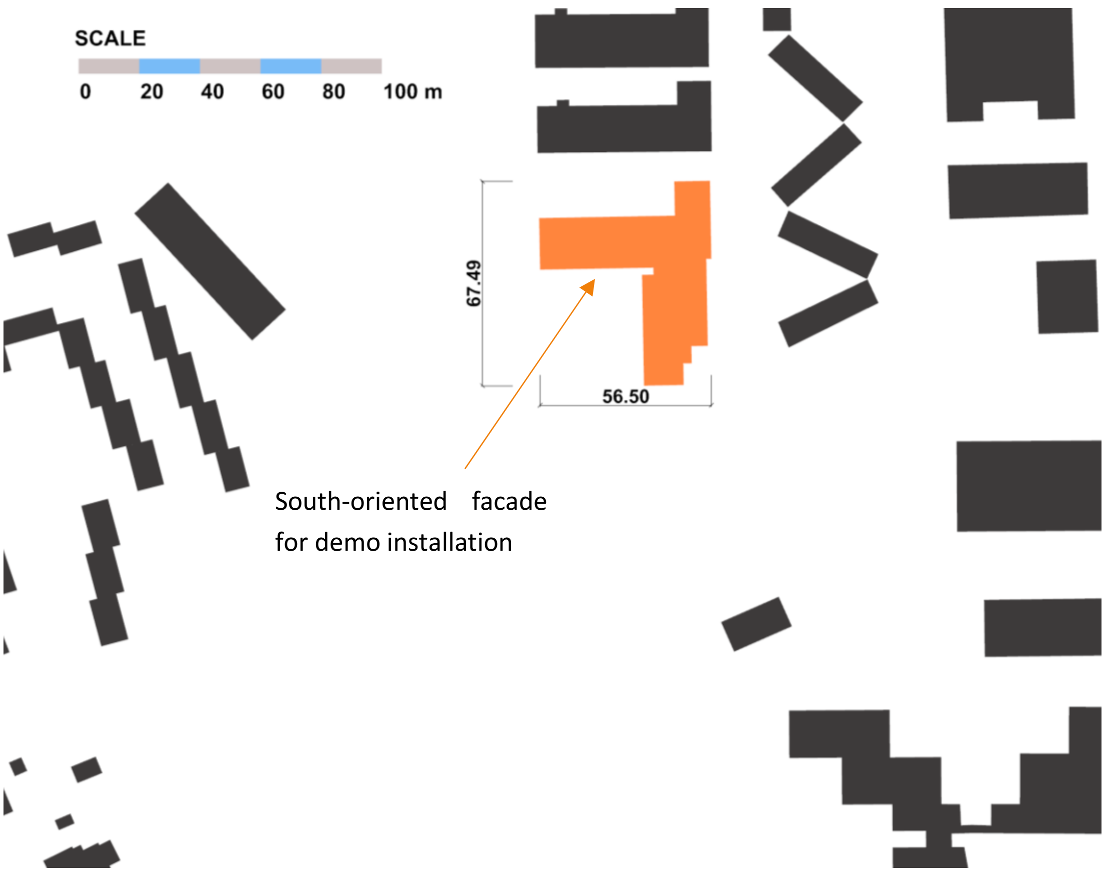


FIGURE 8: LOCAL SITUATION OF THE DEMO BUILDING

3.3.2 Construction

The load-bearing construction is an in-situ exposed concrete. Vertical structures have a variable thickness. The internal ceiling/floor construction has a thickness of 20 cm. The roof has a thickness of 20 cm in most of its area, except for the part, where the air handling units (AHU) are located (here, the thickness is 30 cm). These constructions do not contain any thermal insulation.

The horizontal part of the load-bearing construction (which includes the façade) has a thickness of 20 cm, and it increases to 30 cm in the area of glazing and balconies. An additional plasterboard construction including 40 mm of thermal insulation is placed on the internal side of the façade construction for acoustic purposes. The U-value of the opaque part of the façade is 0.69 $W\cdot m^{-2}\cdot K^{-1}$. The basic module of the building created by the load-bearing structure is 7.20 m. This module is then refined by additional partitions into 3.60 m in most of the building.

Transparent parts of the façade consist of double-glazed façade construction in the entire height of the floors. The position of the façade system is recessed relatively to the load-bearing construction. The glazing U-value with the low-emission coating is 2.8 $W\cdot m^{-2}\cdot K^{-1}$. Figure 9 shows the rooms' typical floor plans adjacent to the southern façade selected for the demo installation.

3.3.3 Building systems

The electrical energy is supplied by a local high voltage central (15 kV). The electrical energy is used for the overall building operation, including the operation of AHUs and for heat supply.

Internal spaces are mechanically ventilated without any heat recovery and with constant airflow. The ventilation system is also used for heating. The supply air is, when needed, heated up by water radiators, (supply water temperature 41 °C, return water temperature 36 °C). When heating is in operation, it is controlled by a programmable manual thermostat, generally set to 22 °C. The internal spaces are not cooled.

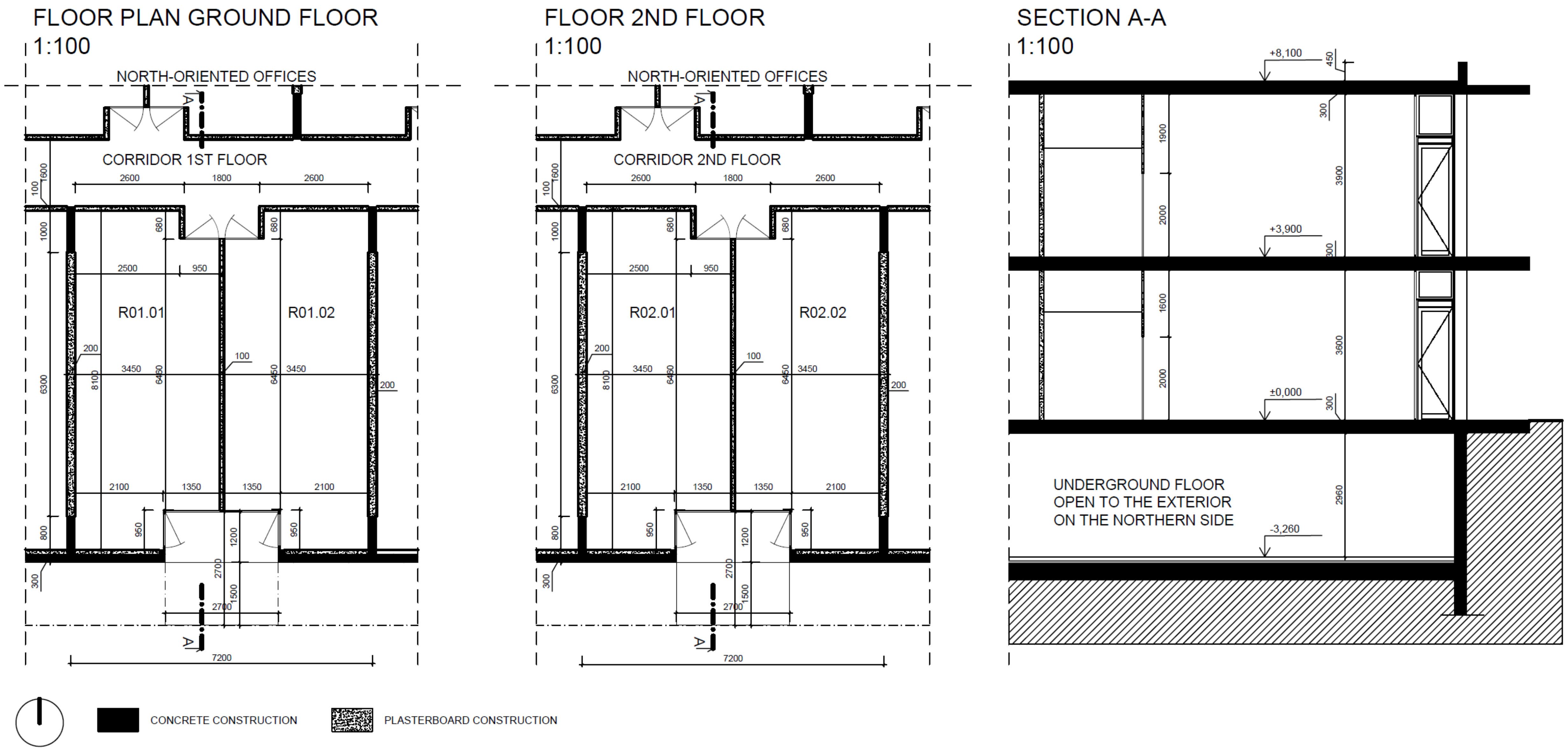


FIGURE 9: FLOOR PLANS AND SECTIONS OF ROOMS BEHIND THE POWERSKIN+ INSTALLATION

3.4 Demo integration

As per Figure 8, the southern façade of the building has been chosen for the demo installation. Plans and sections shown in Figure 9 correspond with the intended demo installation, and the structure of the 3D model described later.

Figure 10 specifies the installation lot in the view to the façade. The installation spot covering two offices on the ground floor and two offices on the 2nd floor, having dimensions of 7.18 m x 7.8 m, providing a total area for installation of 56 m^2.

As individual modules are under development and their final production dimensions are to be defined, the demo kit's detailed design cannot yet be reported. It will be therefore included in the next WP8 deliverable.

The building itself does not use any on-site energy generation and harvesting and the total integration of the active façade into the building system would be impractical. A system of energy harvesting and its potential use in the directly affected rooms will be designed based on the actual module setup. As the concrete part of the façade is load-bearing and cannot be removed, the POWERSKIN+ demo will be installed in front of it, creating a new inner space in the balcony area serving as a dedicated temporary technical space for all the energy storage, harvesting and dispense systems.

The area in front of the building is sufficient and available for installation requirements – demo kit delivery, installation works with mechanisation.

No legal and administrative processes have to be undertaken in order to install the demo.

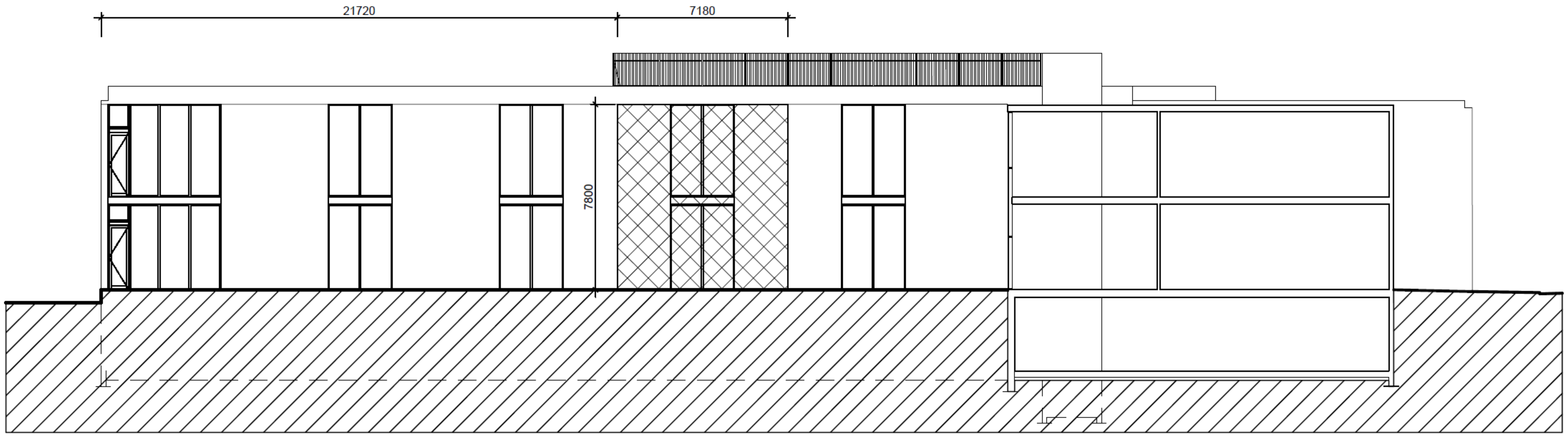


FIGURE 10: VIEW TO THE SOUTH-ORIENTED FACADE WITH THE PLANNED INSTALLATION SPOT

3.5 Demo site 3D model

3.5.1 Model of the building

A 3D model of the building and its surroundings has been created in the Rhino software [7] for further analysis. Thanks to its Grasshopper parametric plugin and the sets of computational plugins such as LadybugTools, the model can be used to prepare definitions for energy simulations in OpenStudio, EnergyPlus etc., as well as for visual comfort analysis and other analysis, which may be needed in the course of the project development.

A detailed geometry model has been created for the four rooms, which will be directly affected by the demo installation. Layers and sublayers based on the type of construction and its boundary conditions have been created. The logic of the layers is as follows:

- Building
    - 1st floor
        - R01.01
            - External walls (external conditions)
            - Glazing (external conditions)
            - Internal concrete wall (adiabatic condition)
            - Internal plasterboard wall (adiabatic condition)
            - To corridor (adjacent to the Corridor 1st floor zone)
            - Internal plasterboard to other modelled room (adjacent to R01.02)
            - Ceiling (adjacent to R02.01)
            - Floor (external conditions)
        - R01.021
            - External walls (external conditions)
            - Glazing (external conditions)
            - Internal concrete wall (adiabatic condition)
            - Internal plasterboard wall (adiabatic condition)
            - To corridor (adjacent to the Corridor 1st floor zone)
            - Internal plasterboard to other modelled room (adjacent to R01.01)
            - Ceiling (adjacent to R02.02)
            - Floor (external conditions)
        - Corridor 1st floor
            - Floor (external conditions)
            - Ceiling (adjacent to the Corridor 2nd floor zone)
            - To offices (adjacent to R01.01 and R01.02)
            - Adiabatic (adiabatic condition on direction to the north-oriented offices)
    - 2nd floor
        - R02.01
            - External walls (external conditions)
            - Glazing (external conditions)
            - Internal concrete wall (adiabatic condition)

[7] McNeel, *Rhinoceros*, version 6.3, n.d., Rhino3d.com.

        - Internal plasterboard wall (adiabatic condition)
        - To corridor (adjacent to the Corridor 2nd floor zone)
        - Internal plasterboard to other modelled room (adjacent to R02.02)
        - Roof (external conditions)
        - Floor (adjacent to R01.01)
    - R02.02
        - External walls (external conditions)
        - Glazing (external conditions)
        - Internal concrete wall (adiabatic condition)
        - Internal plasterboard wall (adiabatic condition)
        - To corridor (adjacent to the Corridor 2nd floor zone)
        - Internal plasterboard to other modelled room (adjacent to R02.01)
        - Roof (external conditions)
        - Floor (adjacent to R01.02)
    - Corridor 1st floor
        - Floor (adjacent to Corridor 1st floor)
        - Roof (external conditions)
        - To offices (adjacent to R02.01 and R02.02)
        - Adiabatic (adiabatic condition on direction to the north-oriented offices)
  - Rest of the building (outline of the vertical constructions of the building; this layer and its sublayers are only used as context geometry)
    - Balconies and overhangs
    - Roof
    - Floor

The model follows the logic of EnergyPlus and OpenStudio, where the construction between two zones is modelled for each zone separately with different orientation.

3.5.2 Model of the surroundings

Model of the surroundings with the shading potential for selected façade of demo installation has also been created in the Rhino environment. It includes the terrain, approximate shape of the trees and the shape of buildings. It only contains the shading elements which may be visible from the southern façade of the demo building. The model consists of more than 1.6 million mesh faces. A view of the building and surroundings 3D model is shown in Figure 11 with the demo building highlighted.

FIGURE 11: 3D MODEL OF THE IPN DEMO BUILDING AND SURROUNDINGS

3.6 Photo documentation of the IPN demo building

FIGURE 12: IPN BUILDING C (SOUTH FAÇADE) – PROPOSED LOCATION FOR THE DEMO

FIGURE 13: IPN BUILDING C (SOUTH FAÇADE) – OUTSIDE WINDOWS AND DOORS

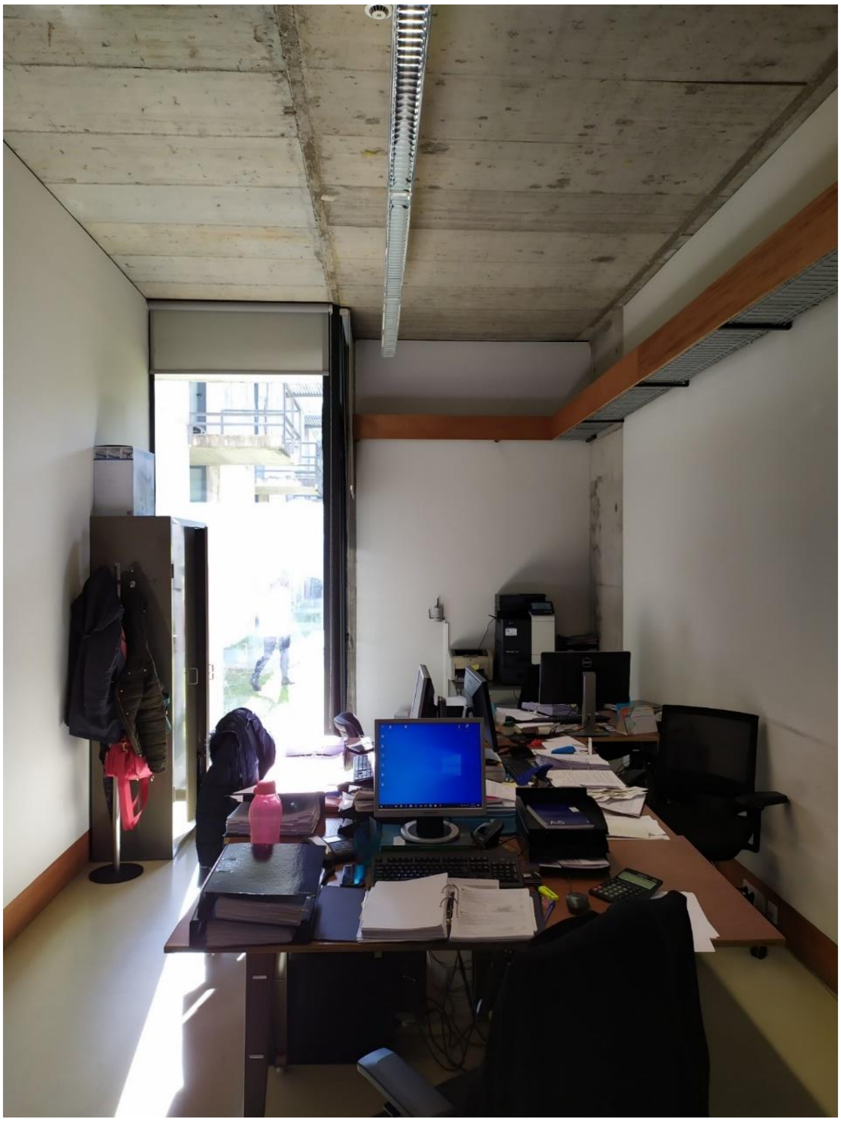


FIGURE 14: IPN BUILDING C (SOUTH FACADE) – OFFICE

4. Demo NAVODNIK

During the project proposal stage and at the beginning of the project, it was envisioned to integrate the POWERSKIN+ demo at the elementary school A.T. Linharta in Radovljica, Slovenia (SLO), shown in Figure 15.

FIGURE 15: NAVODNIK PROPOSED DEMO BUILDING IN RADOVLJICA (SLO)

Due to unforeseen administrative problems associated with the demo installation (securing a contract with the school owner – The State of Slovenia) and safety restrictions, two alternative locations have been proposed by the consortium members, within the framework of the project contingency plan as a mitigation action to secure the work program. The main alternative, Alternative A, represents an administrative part section of the NAVODNIK d.o.o. factory building in Celje, Slovenia. Alternative B consist of two buildings in the FLACHGLAS SACHSEN factory in Sülzfeld, Germany (GER).

4.1 Alternative 1: Slovenia

A site visit was conducted by a CVUT team in order to assess the proposed alternative and collect information and technical drawings of the building.

4.1.1 Alternative A location

The proposed building is located in a factory area of the city of Celje in Slovenia. It lies in the proximity of the A1 highway (E57). The location is approximately 5 km from the A1 highway. The city of Celje is located on the southern border of the Savinja valley between the Pohorje mountains in the north and the Sava Hills in the south.

FIGURE 16: LOCATION OF THE CITY OF CELJE (SLO) AT A LARGER SCALE[8]

FIGURE 17: LOCATION OF THE CITY OF CELJE (SLO) AT MEDIUM SCALE[9]

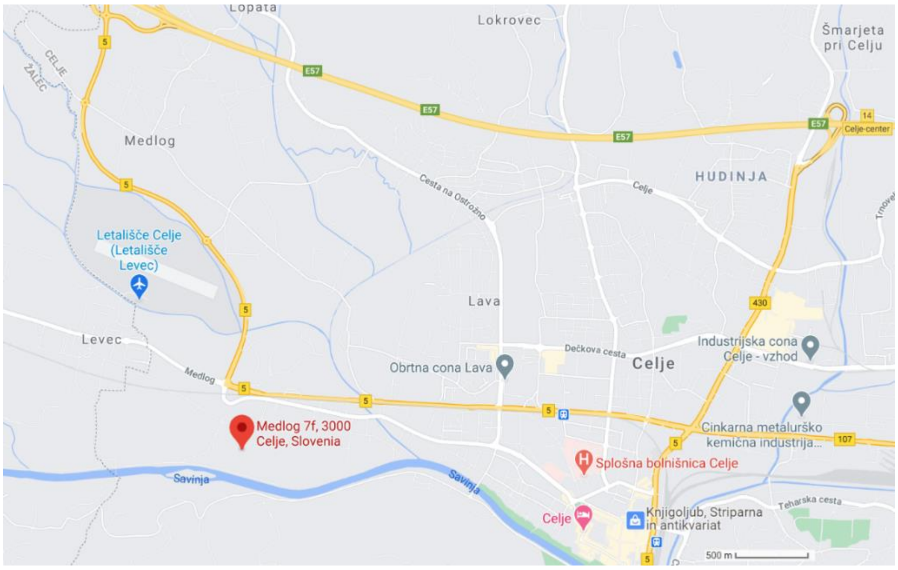


FIGURE 18: LOCATION OF DEMO SITE WITHIN THE CITY OF CELJE (SLO)[10]

[8] 'Google Maps', Google Maps, accessed 12 August 2020, https://www.google.com/maps/@44.6486366,11.4606858,6.63z?hl=en.
[9] 'Google Maps', Google Maps, accessed 12 August 2020, https://www.google.com/maps/@46.1077848,15.136685,10.69z?hl=en.
[10] 'Google Maps', Google Maps, accessed 12 August 2020, https://www.google.com/maps/@46.221573,15.2506209,13.94z?hl=en.

4.1.2 Climate analysis of the demo location

The differences between the older and newer climate data have been discussed in section 3.2 when describing the climate in Coimbra, Portugal. Only the latest weather data (derived from measurements between 2004 and 2018) processed by climate.onebuilding.org will be presented for other locations. The weather station in Celje for which this dataset exists is located at the nearby Celje airport.

Figures below show the results of the climate analysis for Celje. The data confirm the Cfb characteristic (temperate oceanic climate) according to the Köppen classification. In contrast to the previously described demo location in Coimbra, Portugal, the winter temperatures regularly drop below 0 °C. The lowest air temperature, according to the weather file, is -12.8 °C. This leads to higher thermal insulation standards and typical use of thermal insulation in new and refurbished buildings.

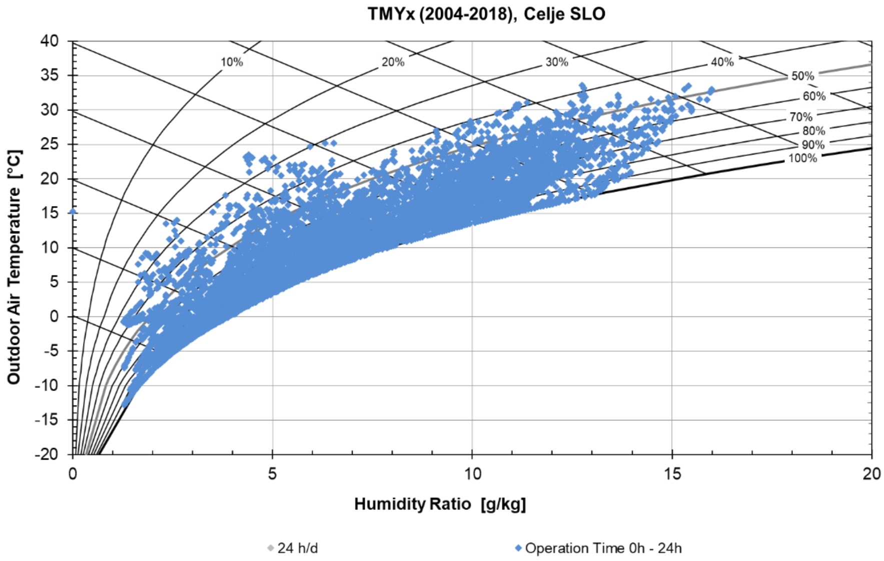


FIGURE 19: CLIMATE ANALYSIS FOR CELJE (SLO): THE AIR TEMPERATURE AND HUMIDITY RELATION

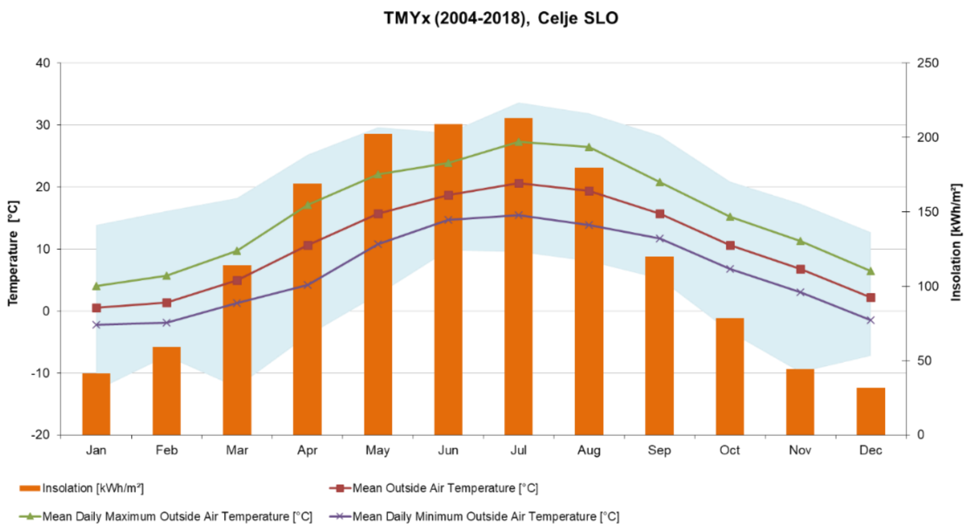


FIGURE 20: CLIMATE ANALYSIS FOR CELJE (SLO): THE AIR TEMPERATURE AND GLOBAL SOLAR IRRADIATION ON A HORIZONTAL PLANE

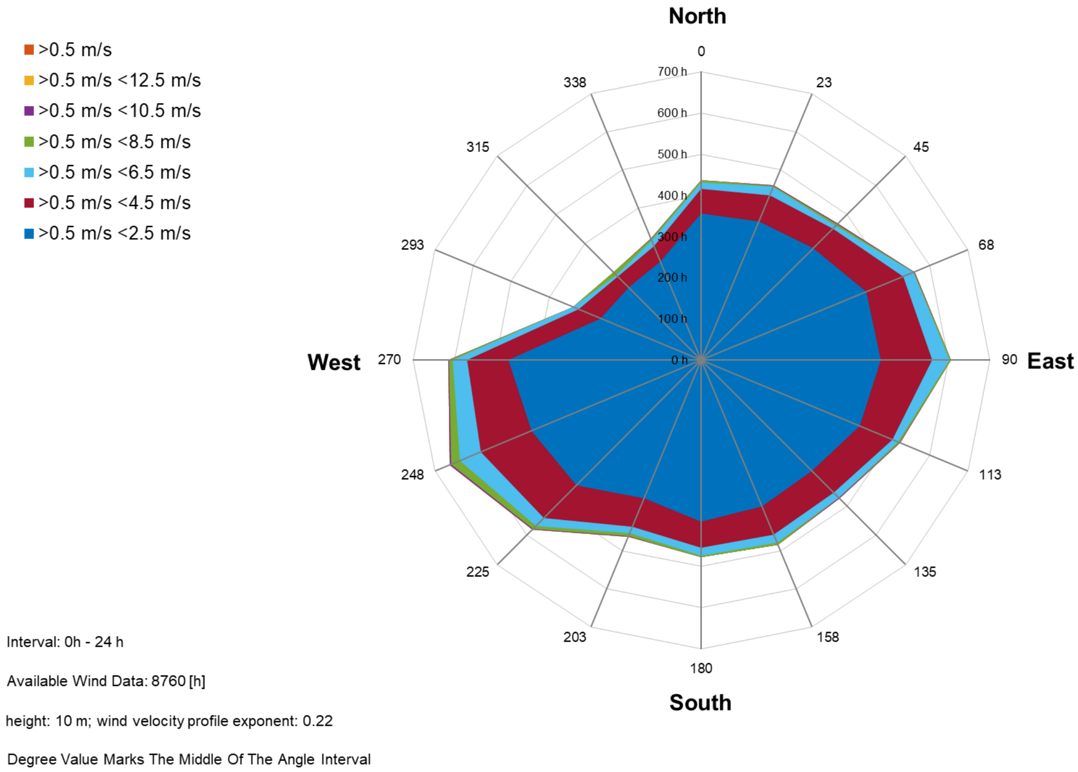


FIGURE 21: CLIMATE ANALYSIS FOR CELJE (SLO): THE WIND SPEED AND DIRECTION

4.1.3 Alternative 1 - General building description

The building in Celje is a factory building built in 1980. The main façade orientation is to the east. The building consists of a main factory hall and support laboratories, offices and staff rooms. The factory hall takes up the western part of the floorplan with the other rooms being adjacent to the main eastern façade. From the south, the building is adjacent to another structure. Figure 22 shows the local situation at the possible Demo site with surrounding buildings and Figure 23 shows the east-facing façade and the spot identified for possible installation.

The building is not permanently occupied and there is no fixed operation schedule in place.

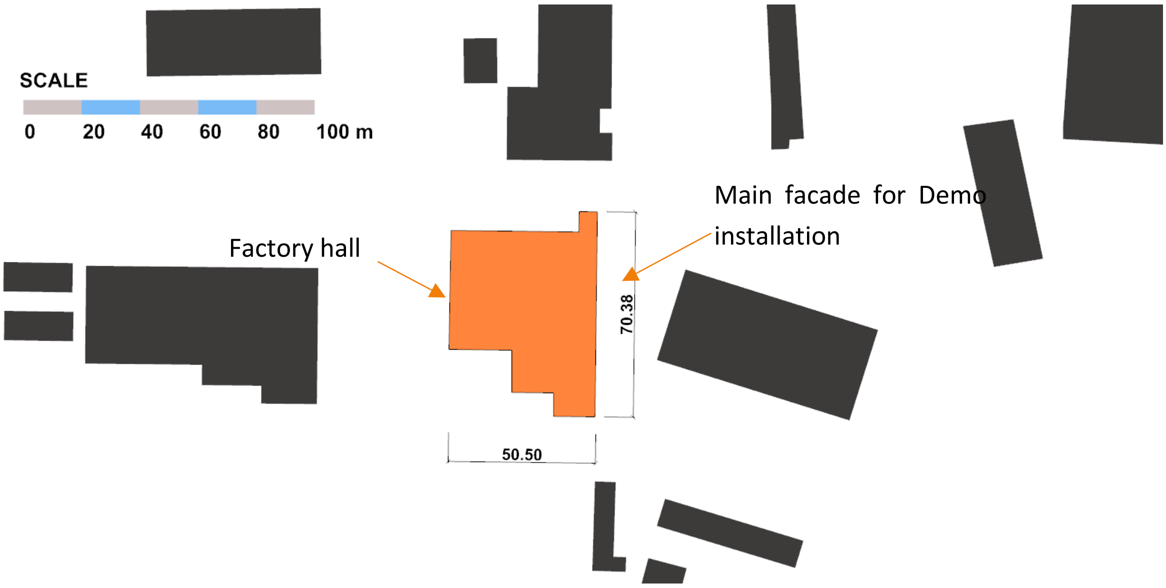


FIGURE 22: LOCAL SITUATION OF THE ALTERNATIVE 1 DEMO BUILDING

FIGURE 23: VIEW TO THE POSSIBLE INSTALLATION FAÇADE

4.1.1 Alternative 1 - Building construction

The load-bearing structure of this alternative building is a concrete frame with a basic module of 6 meters. The first and last field of the frame have a reduced module of five meters. The concrete columns of a square section have a dimension of 400 mm. The frames bear beams parallel with the main façade on top of which the roof-bearing beams perpendicular to the main façade are placed. The façade between the columns is created from a non-load-bearing concrete block with a thickness of 300 mm with no thermal insulation.

The building consists of one level with different floor heights. There are two entrances in the main façade, both separately servicing parts of the support rooms.

The roof itself consists of concrete panels with trapezoid sheet metal on top of it. Some of the internal rooms have suspended ceilings made of either timber or plasterboards.

Different materials are also used for internal partitions. Some of them are constructed from the same concrete blocks as the façade, some are constructed from ceramic bricks, and some are timber-based.

Windows used in the façade vary from single-glazed timber windows, along with double-glazed timber windows (with simple double-glazing) to plastic windows with double-glazed IGUs.

4.1.2 Alternative 1 - Building systems

The building is connected to the electrical grid. Even though there are radiators in some of the rooms, as well as the necessary piping, gas supply and a chimney, there is no heat source for this system in the building. During its operation, the building is heated with the internal gains from the machinery and production, which is occasionally supported by local electrical heat sources.

4.1.3 Alternative 1 - Integration possibilities

After discussing the different possibilities, the consortium's technical staff has reached an agreement on the possible integration spot shown previously in Figure 23. Currently, there is a single room behind the highlighted area which has the floor raised relatively to the rest of the building. The consortium has agreed that this room should be divided into two similar rooms, thus offering the possibility of a side-by-side comparison which would excel the project needs in terms of the future on-site evaluation of the developed façade solutions. The new partition in the middle room B.07 will create two rooms: B.07a and B.07b with the same geometry. The façade of one of these rooms will then serve for the demo installation, while the other remains unchanged. The area for demo installation is foreseen to be 2.45 m x 2.83 m = 6.93 m^2. The advantage of this solution is the possibility of monitoring and comparing two rooms with similar dimensions and boundary conditions, before (baseline) and after the demo installation.

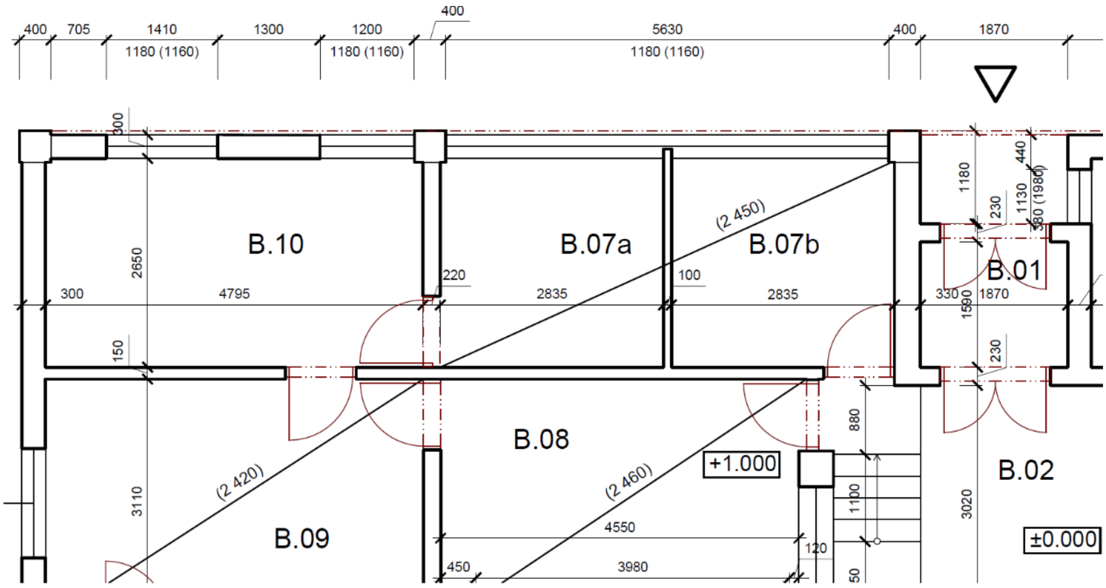


FIGURE 24: ALTERNATIVE 1 – FLOOR PLAN ADJUSTMENT FOR DEMO INSTALLATION

4.2 Alternative 2: Germany

Another alternative to the initial demo site has been recently proposed by the POWERSKIN+ partner FLACHGLAS SACHSEN. It includes two buildings for possible demo installation. However, before a decision is made between the two alternatives for the mitigation action, more information on alternative 2 is needed, which was not available before the submission of this report.

4.2.1 Alternative 2 - Location

The proposed buildings are located in the town of Sülzfeld in central Germany – in the federal state of Thüringen. The location lies at the foothills of the Rhön mountains. To the south, it has a clear view of the valley between the mountains, which eliminates the shading effects of the mountains on the south-oriented facades proposed for the demo installation. The location is near the federal motorway number 71.

FIGURE 25: LOCATION OF THE TOWN OF SÜLZFELD (GER) AT A LARGER SCALE[11]

FIGURE 26: LOCATION OF THE TOWN OF SÜLZFELD (GER) AT MEDIUM SCALE[12]

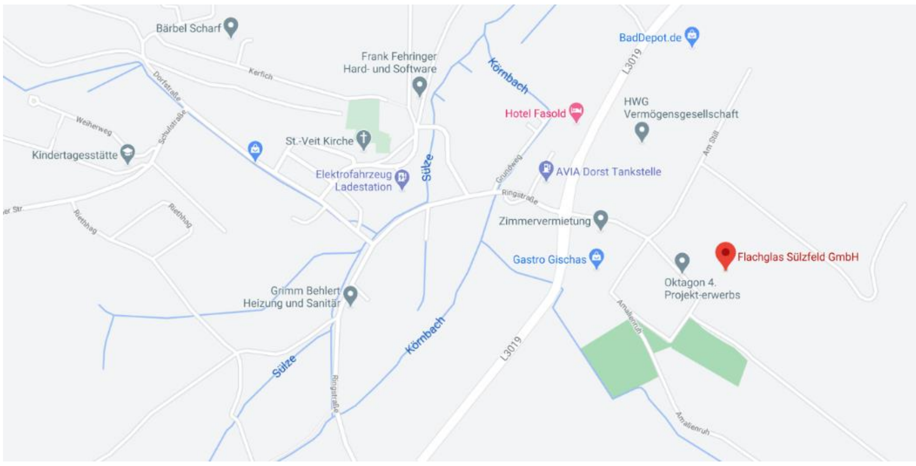


FIGURE 27: LOCATION OF DEMO SITE WITHIN THE TOWN OF SÜLZFELD (GER)[13]

[11] 'Google Maps', Google Maps, accessed 20 December 2020, https://www.google.com/maps/@49.7326742,8.7109418,6.55z?hl=en.
[12] 'Google Maps', Google Maps, accessed 20 December 2020, https://www.google.com/maps/@50.5083817,10.3736734,11.96z?hl=en.
[13] 'Google Maps', Google Maps, accessed 20 December 2020, https://www.google.com/maps/@50.5204018,10.3647063,16.03z?hl=en.

4.2.2 Alternative 2 - Climate analysis of the demo location

The nearest weather station with the new TMYx weather file processed with comparable boundary conditions is in the city of Fritzlar (approximately 100 km away). The Figures below show the results of the climate analysis for Fritzlar.

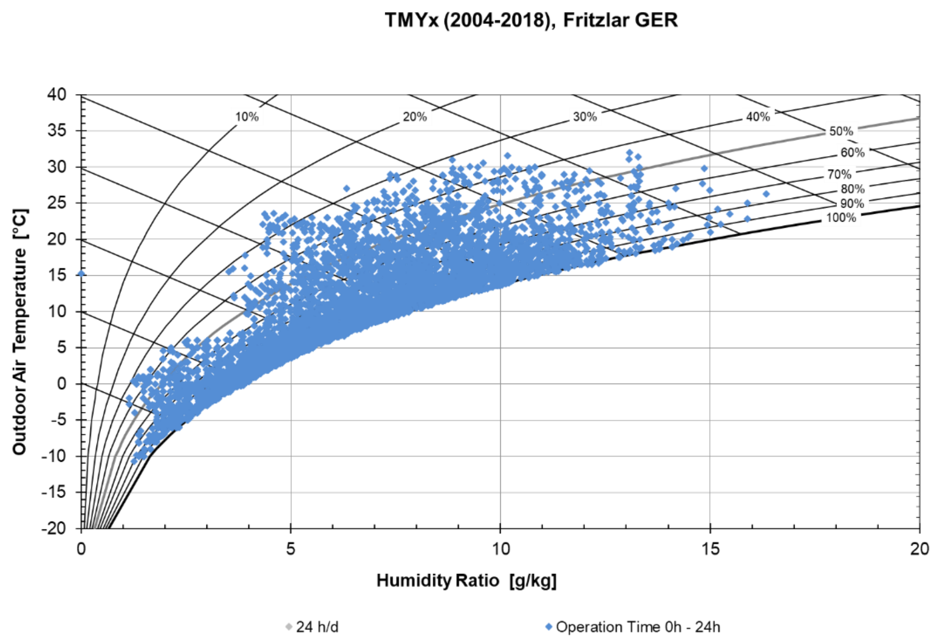


FIGURE 28: CLIMATE ANALYSIS FOR FRITZLAR (GER): THE AIR TEMPERATURE AND HUMIDITY RELATION

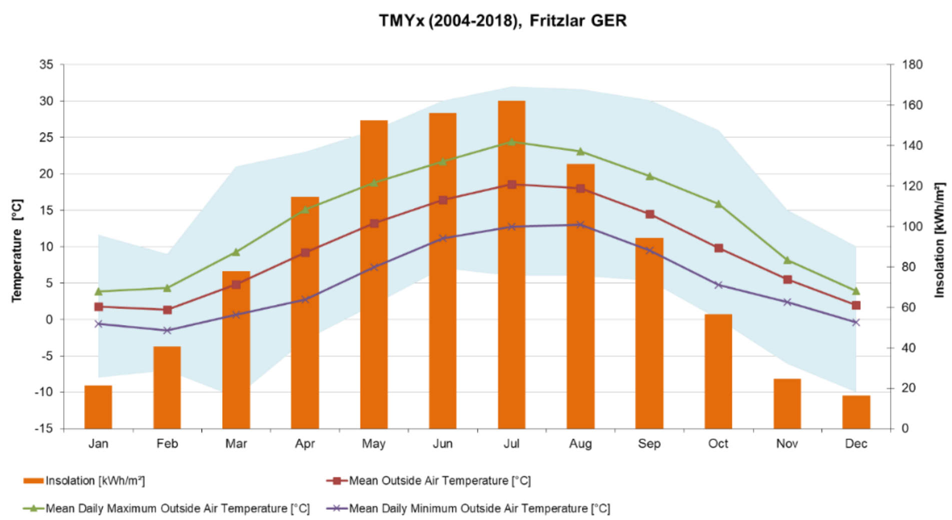


FIGURE 29: CLIMATE ANALYSIS FOR FRITZLAR (GER): THE AIR TEMPERATURE AND GLOBAL SOLAR IRRADIATION ON A HORIZONTAL PLANE

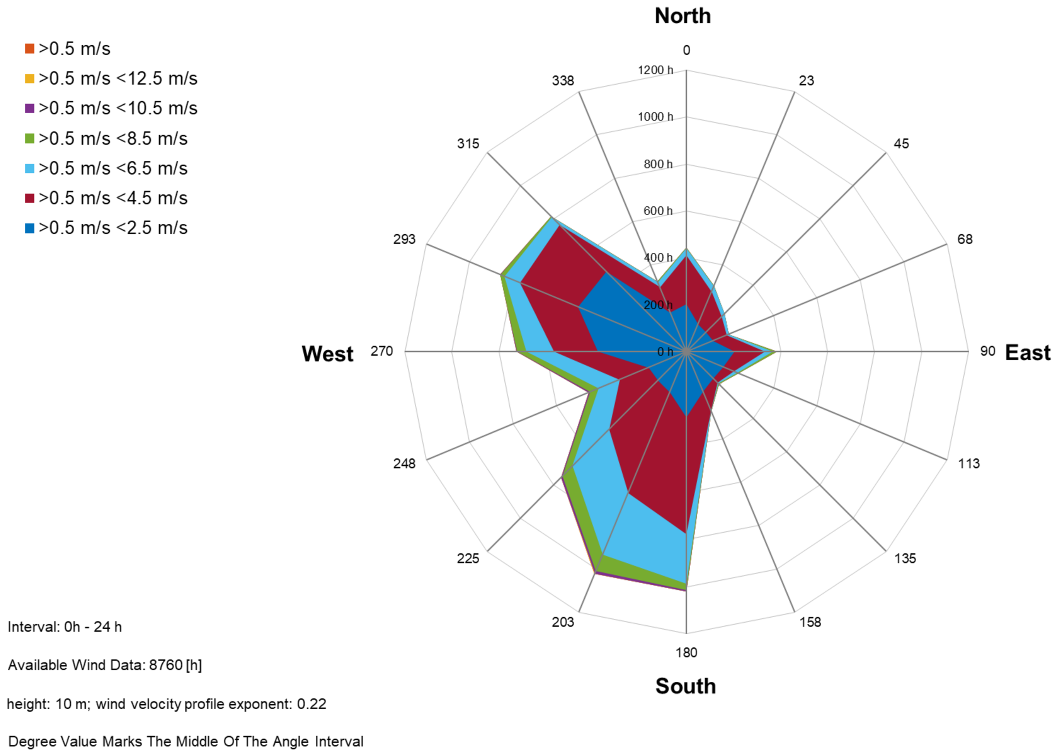


FIGURE 30: CLIMATE ANALYSIS FOR FRITZLAR (GER): THE WIND SPEED AND DIRECTION

4.2.3 Alternative 2 - General building description

As shown in Figure 31, two possible façades for the demo installation are proposed for this mitigation action. Both buildings have a load bearing structure in the form of a concrete frame. Their facades, however, are different. The first building B.01 has a glazed façade with some opaque parts, whereas the building B.02 has a façade made of concrete panels.

The buildings also serve different purposes. The B.01 is the main building, and it serves as a factory with technical and staff rooms. This façade, intended for the demo installation faces a parking lot existing at the building entrance, making the installation spot visible to the company visitors, which are generally received in the building and will have the opportunity to be briefed about the multiple PS+ developed solutions and see them in action. The B.02 building serves as a storage. The façade of this building available for the demo installation faces a slope and is therefore not visible to almost anyone. A view to both facades is shown in Figure 32 (B.01) and Figure 33 (B.02), respectively.

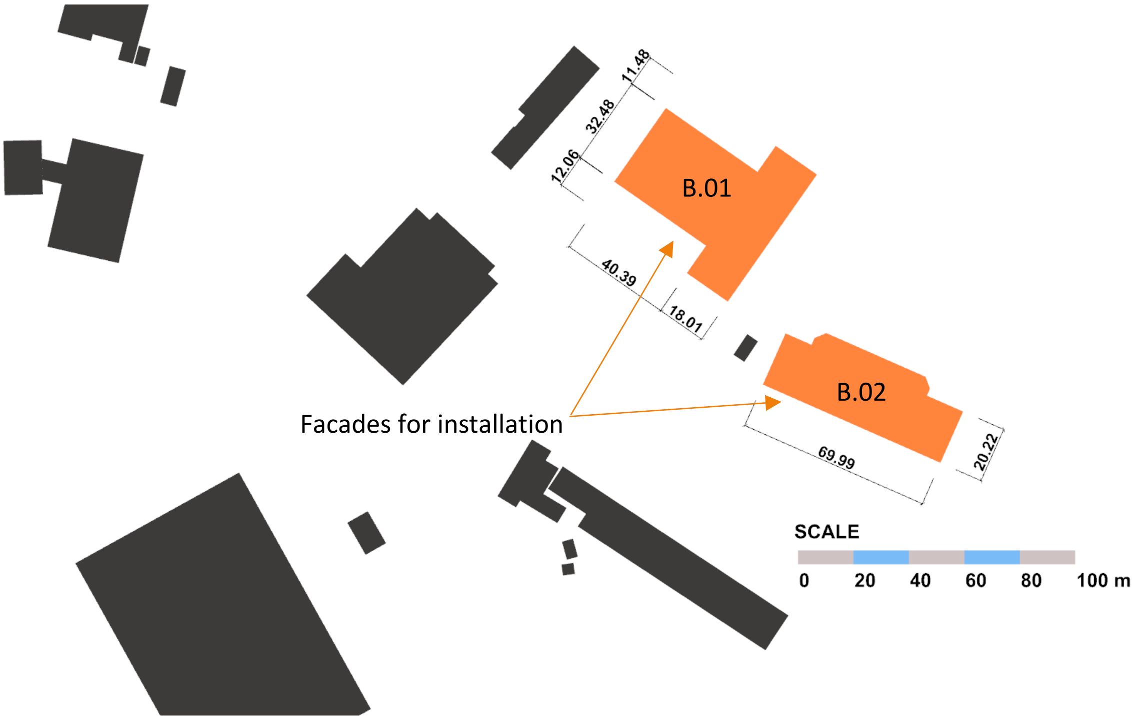


FIGURE 31: LOCAL SITUATION OF THE ALTERNATIVE 2 DEMO BUILDING

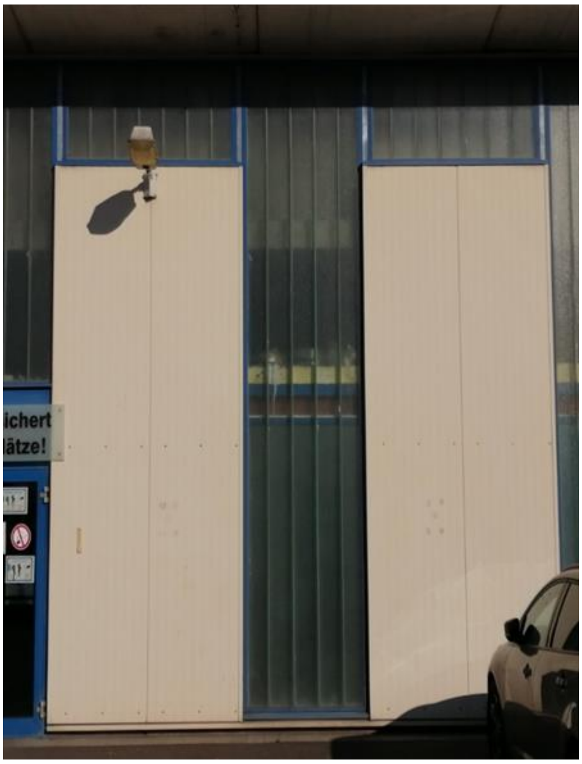


FIGURE 32: VIEW TO THE FACADE OF B.01

FIGURE 33: VIEW TO THE FACADE OF B.02

5. Demo CVUT

5.1 Demo location

The demo installation location is the building of the UCEEB CVUT in Buštěhrad, Czech Republic. Buštěhrad lies in the Central Bohemian region and is located near the cities of Prague and Kladno. The route from the Prague international airport to the demo site is approximately 13 km.

The demo site is located near the D7 highway. The terrain near the demo site is flat. The demo site is in a brownfield of a steel factory, which neighbours with the location in the south.

FIGURE 34: LOCATION OF BUŠTĚHRAD (CZE) AT A LARGER SCALE[14]

[14] 'Google Maps', Google Maps, accessed 12 May 2020, https://www.google.com/maps/@51.7602715,10.3810202,5.87z?hl=en.

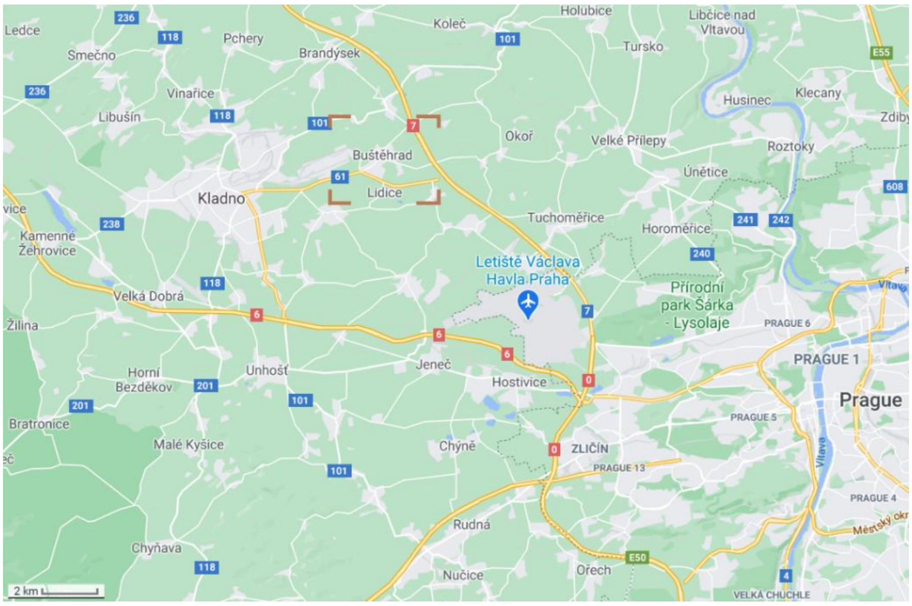


FIGURE 35: LOCATION OF BUŠTĚHRAD (CZE) AT A MEDIUM SCALE[15]

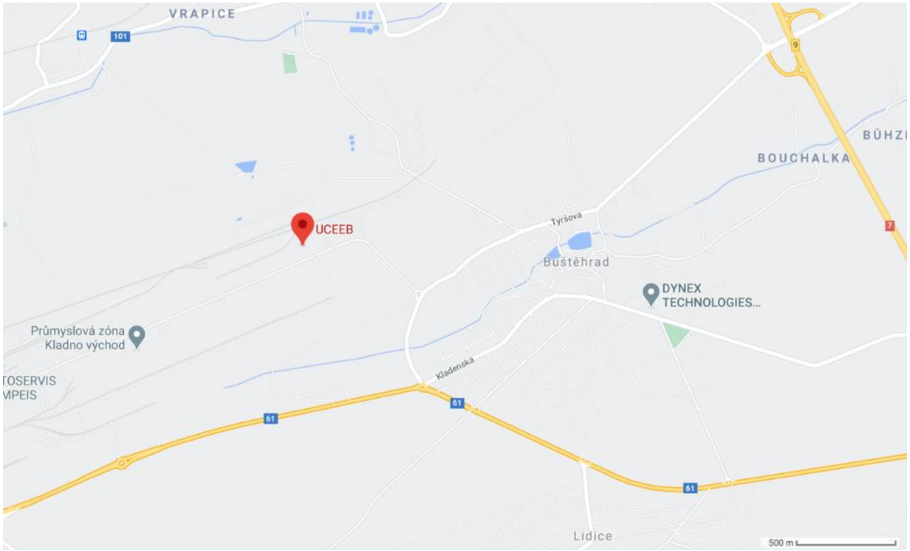


FIGURE 36: LOCATION OF THE DEMO BUILDING WITHIN BUŠTĚHRAD (CZE)[16]

5.2 Climate analysis of the demo location

The nearest weather station with the new TMYx weather file is located at the Prague International Airport, approximately 9 km away (*as the crow flies*). The climate analysis presented in the Figures below shows a similar climate like the one in Celje, Slovenia (the Cfb characterization of the climate according to the Köppen classification).

[15] 'Google Maps', Google Maps, accessed 12 May 2020, https://www.google.com/maps/@50.1132831,14.1850056,11.29z?hl=en.
[16] 'Google Maps', Google Maps, accessed 12 May 2020, https://www.google.com/maps/place/UCEEB/@50.1517958,14.1617701,14.46z/data=!4m5!3m4!1s0x470bc7ed0724e133:0x3b57ba8c20dd1b20!8m2!3d50.1566922!4d14.1695933?hl=en.

According to the weather files, the temperatures can drop to the lowest values as compared to the other demo locations (-16.2 °C), which is crucial when assessing the thermal insulation properties and water vapour condensation in the critical details of POWERSKIN+ modules under real boundary conditions.

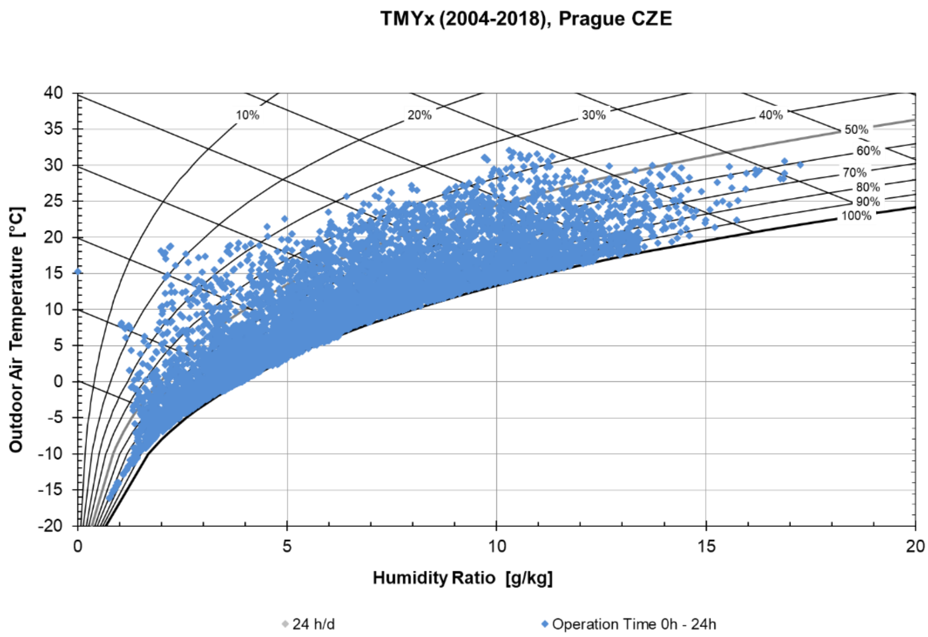


FIGURE 37: CLIMATE ANALYSIS FOR PRAGUE (CZE): THE AIR TEMPERATURE AND HUMIDITY RELATION

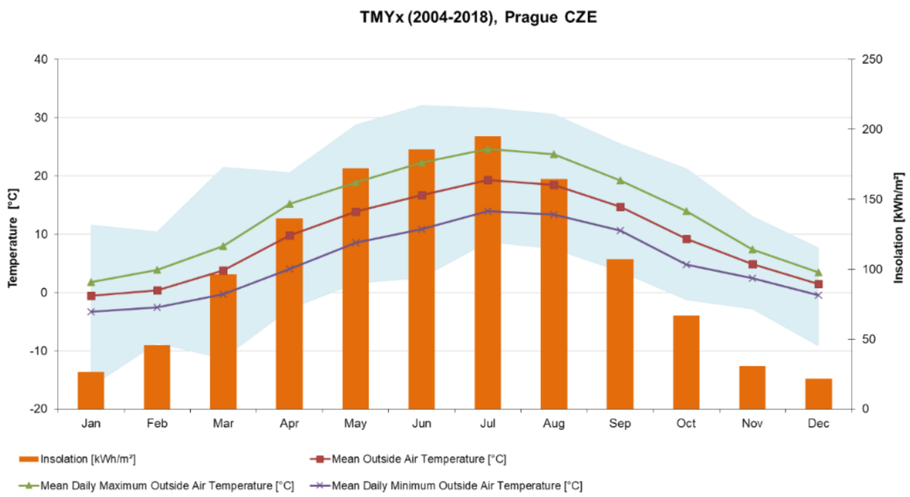


FIGURE 38: CLIMATE ANALYSIS FOR PRAGUE (CZE): THE AIR TEMPERATURE AND GLOBAL SOLAR IRRADIATION ON A HORIZONTAL PLANE

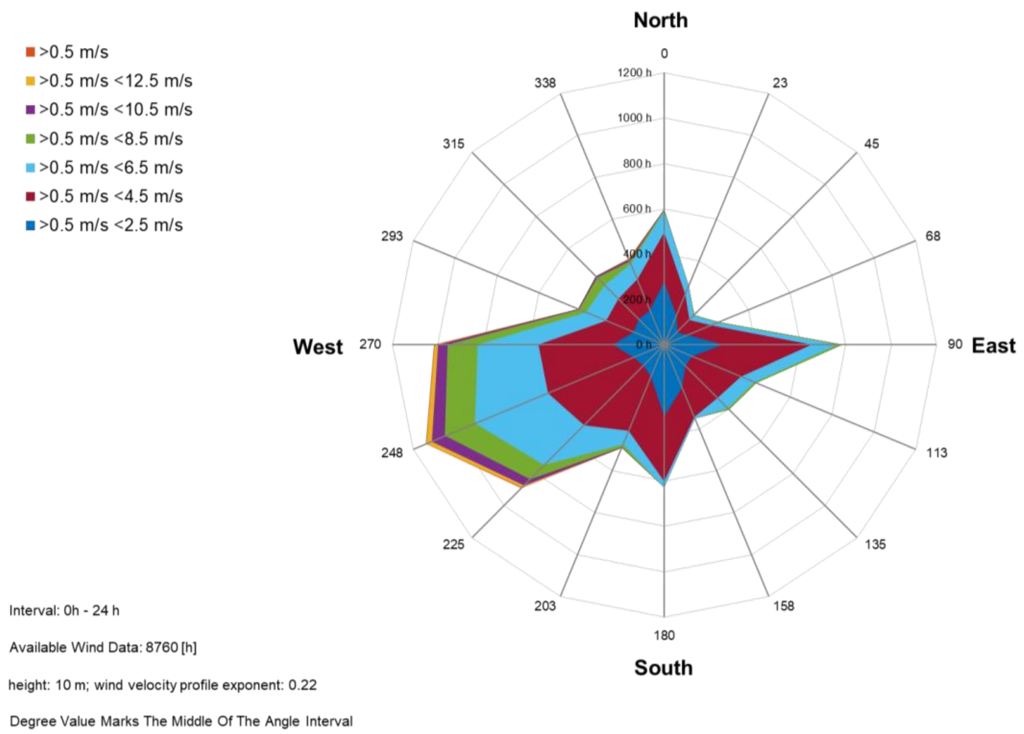


FIGURE 39: CLIMATE ANALYSIS FOR PRAGUE (CZE): THE WIND SPEED AND DIRECTION

5.3 Demo building description

5.3.1 General description

The UCEEB building was constructed between 2012 and 2014. It serves as a university research centre. It consists of an administrative part, laboratories and the main testing hall. The laboratories cover a large range of research fields, from hydrometeorology and hydropedology, through composite building materials, mechanical research, solar simulator, building hydrothermal research, indoor environment research, building energy systems to fire safety of the buildings and materials. Figure 40 shows the floor plans of the two above-ground levels of the building, and Figure 42 as well as Figure 42 show cross-sections through the building.

There is an ongoing climate measurement in place using three weather stations (on the roof, in the north-western and in the south-eastern part of the grounds). The air temperature and relative humidity are also monitored in most of the indoor spaces.

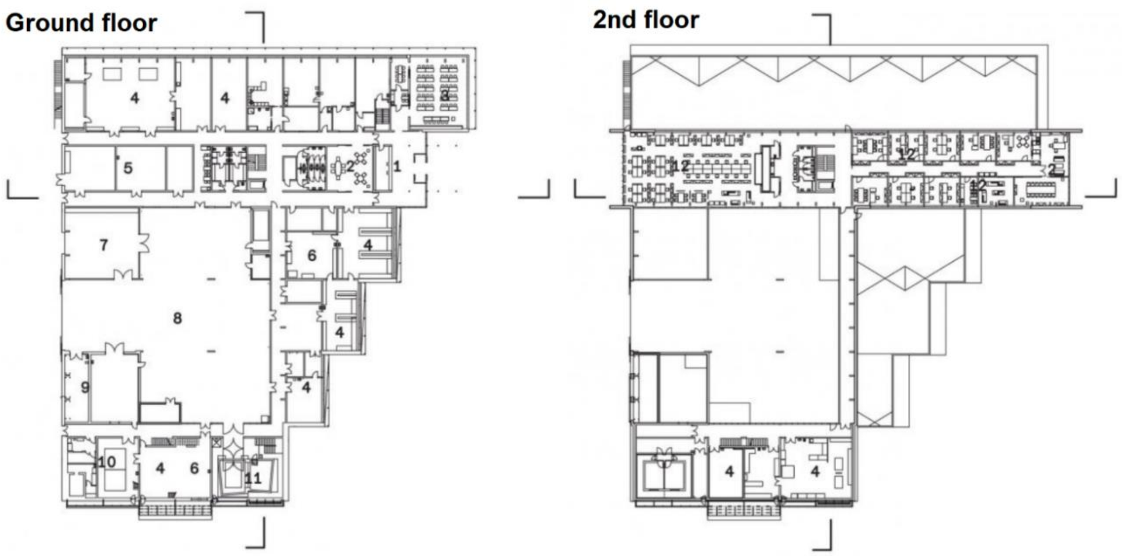


FIGURE 40: UCEEB DEMO BUILDING FLOOR PLANS

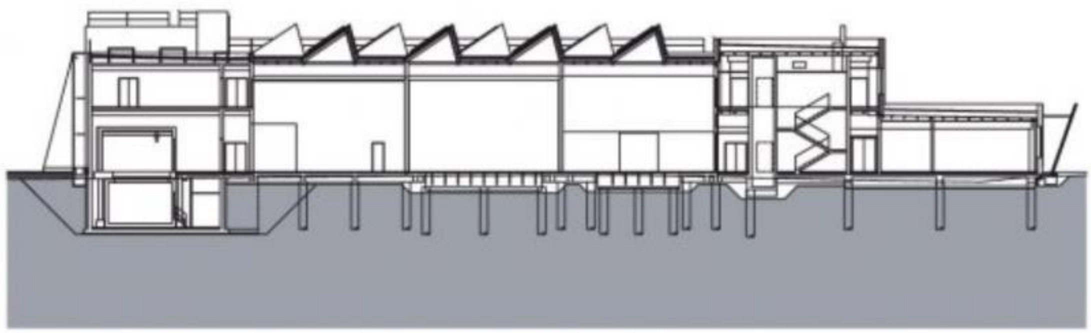


FIGURE 41: UCEEB DEMO BUILDING CROSS-SECTION

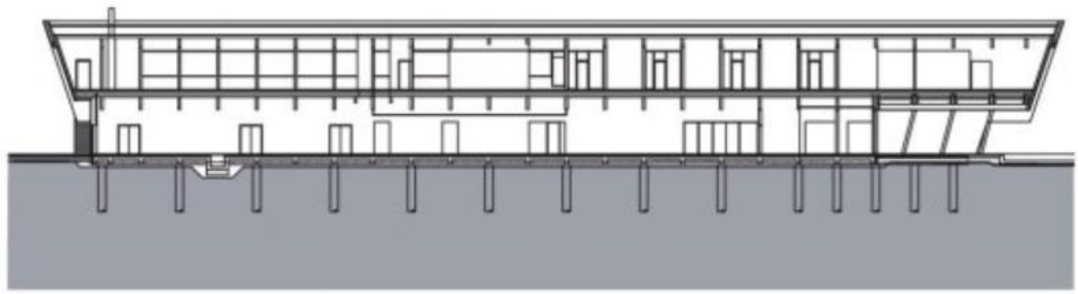


FIGURE 42: UCEEB DEMO BUILDING CROSS-SECTION

5.3.2 Construction

The building's construction system combines a wall system with in-situ concrete walls with a heavy timber skeleton. Transparent parts are triple glazed with low emissivity coatings. The building envelope meets the local recommended values for passive buildings.

5.3.3 Building systems

The building uses multiple energy sources. Apart from the electrical grid, it also uses two gas microturbines with a total electrical power of 95 kW, photovoltaic on the roof with 35 kWp, experimental photovoltaic on the southern façade with 12 kWp and ORC units, which are being developed and tested with 8 kW.

The electricity demand can be balanced using a 50 kWh Li-ion battery storage with maximal current of 250 – 300 A. The battery storage is controlled using an advanced battery management system.

Heating energy is supplied by the microturbines mentioned above (185 kW in total), ORC units and two gas boilers (100 kW each).

Cooling energy can be supplied by a compressor unit (260 kW) and sorption units that can utilize the thermal energy produced by the microturbines in summer (approximately 80 kW).

The building system design allows connecting additional energy (electrical and thermal) sources, making it possible to utilize the energy produced by experiments and technology testing.

5.4 Demo integration

The demo will be installed on the experimental southern façade of the UCEEB building. A steel construction there is flexible for any element installation. Currently, there are running experiments with timber-based curtain walls, photovoltaic installations and a solar chimney. The total area available for installation is roughly 50 m^2. The drawings of the installation spot are shown in Figure 43. The actual demo size will be determined according to POWERSKIN+ modules production capacity and also to the final sizes of the other demo installations in the project.

The area available for the installation on the southern façade is currently fully glazed with a single-glazing. The wall behind the façade is heavily thermally insulated (30 cm of EPS), and the gap between the glazing and the external surface of the wall is 100 cm. Within this gap, a new dedicated room will be constructed for the operational stage of the POWERSKIN+ demo. This artificial room will be conditioned as an indoor office environment, capturing the POWERSKIN+ modules and add-ons' performance under real boundary conditions. The energy harvesting systems will then be connected to the building energy systems using the available electrical and hydraulic connection points.

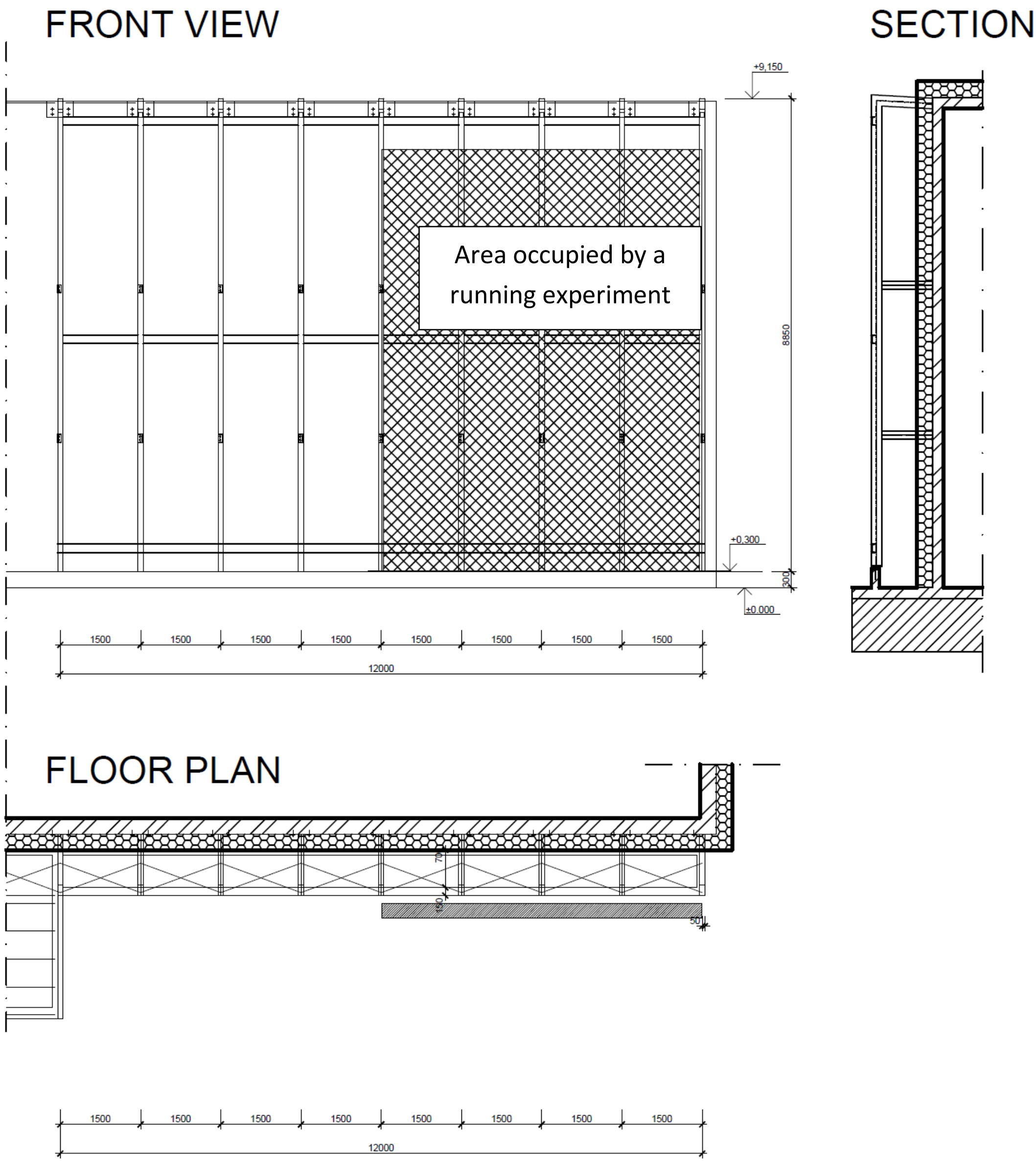


FIGURE 43: DRAWINGS OF THE SOUTHERN FACADE FOR DEMO INSTALLATION

5.5 Demo site 3D model

A 3D model has been created for the demo site and the building. At this stage, it only covers the building envelope and external structures for mostly solar analysis. No actual thermal zones of the interior have yet been created as this will follow the sizing and placing decisions of the pilot installation. A preview of the model is shown in Figure 44. In this preview, the location of existing weather stations is indicated.

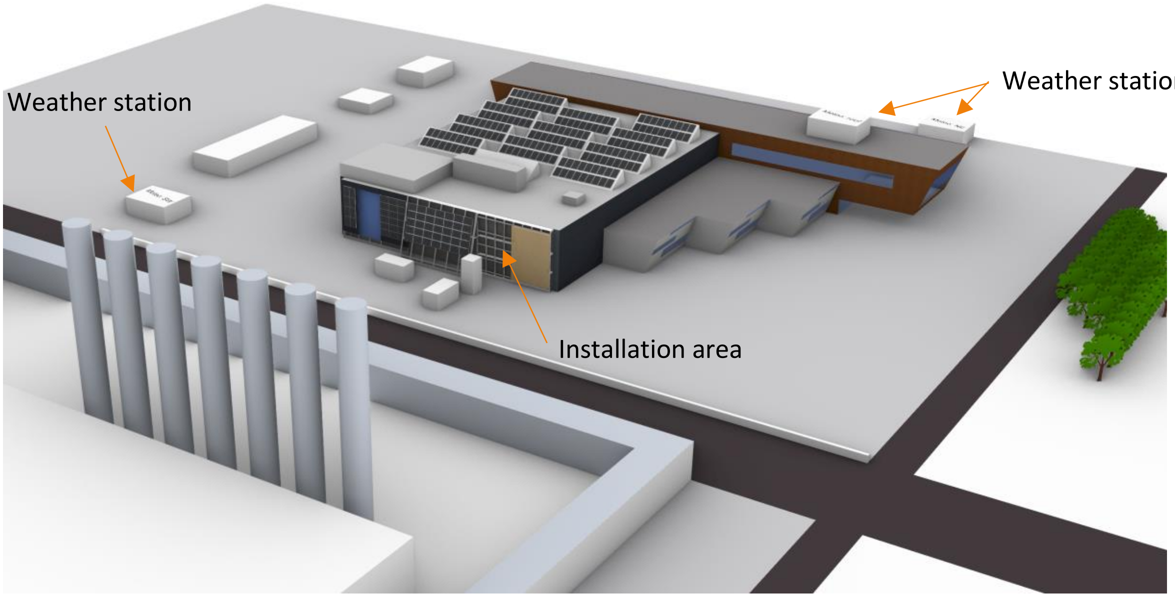


FIGURE 44: 3D MODEL OF THE DEMO SITE AND SURROUNDINGS

6. Baseline monitoring equipment

For the baseline monitoring, a set of sensor and logging equipment is being tendered. The equipment will focus on thermal, solar and visual comfort performance of the demo sites in the baseline conditions. The key sensors and their specifications are listed below:

- Thermal performance of the current façade:
  - PT sensors (placed on the internal and external surface of both opaque and transparent part of the façade): accuracy ± 0.5 °C. PT sensors have been chosen because of higher accuracy when measuring surface temperatures close to 0 °C
  - Heat flux meters (placed on the internal and external surface of both opaque and transparent part of the façade): accuracy ± 3 %
- Solar performance of the current transparent parts of the façade:
  - Class C pyranometers placed in a vertical position in front of and behind the transparent glazing: sensitivity 10 uV/(W/m²)
- Internal user comfort:
  - Class A black globe thermometer to assess the room operative temperature: accuracy ± 0.15 °C
  - Indoor thermo-hygrometers: accuracy ± 0,4 %, sensitivity 0,1 K
  - Photometers to assess visual comfort: measurement error < 5 % in the range of 6 – 10 000 lux
- Outdoor conditions:
  - Propeller anemometer, range 0.6 – 60 m/s,
  - T/RH probe on a 1 m cable + pressure sensor. Temperature range -30 to 105 °C, accuracy ± 0.4 °C; Humidity range 0 – 100 % RH, accuracy ± 2.5 % RH (5.95 % at 23 °C); Pressure range 600 – 1100 hPa, accuracy ± 1.3 hPa at 23 °C

- Data logging equipment:
  - Ethernet, USB, RS232, SDI-12, Modbus, WEB, int. Battery, 5 – 15 analog inputs., 8 digital inputs/outputs; 100 kHz

The equipment is tendered in the amount for three locations with overall four monitored internal rooms (one location with a side-by-side measurement).

7. Conclusion

This document summarizes the preliminary description of three different pilot sites envisaged for POWERSKIN+ project and their boundary conditions. It defines the pilot sites' locations, building constructions, usage and building systems. It also describes the areas on the existing facades, which will be used for POWERSKIN+ installation. 3D models for further analysis and simulations have been created for this initial assessment, including the surrounding context geometry.

Due to unforeseen administrative liabilities that occurred after the beginning of the project and that were impossible to overcome, this report also describes the contingency plan set by the consortium, which is currently assessing two alternative non-residential buildings at different locations to serve as suitable replacers for the initially proposed NAVODNIK demo building.

The document also presents the sensors to be used within the POWERSKIN+ baseline monitoring. The logging equipment will be able to accommodate additional sensors during the course of the project to capture also active properties of the modules.