# LIFE my building is green

LIFE17 ENV/EN/000088

## Application of Nature-Based Solutions for local adaptation of educational and social buildings to Climate Change

Action: Elaboration and drafting of the baseline for pilot buildings

Deliverable: Pilot buildings baseline report

Date: 31/03/2020

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Deliverable: **Elaboration of NBS databases and work matrix**

Date: **31/12/2019**

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# Index

# 1. SUMMARY EN ESPAÑOL

This deliverable includes the indicators selected for assessment the impact of the Project's actions. The indicators have been organized by the environmental and social challenges that schools and social buildings face as spaces present in urban environments.

For each indicator, the evaluation and calculation methodology and a description of the necessary monitoring are presented.

Once the indicators and their methodology have been described, a baseline analysis for the demo buildings that have been selected as demonstrators for the installation of the prototypes of nature-based solutions proposed in the project.

In the study, it can be seen the baseline of the schools of Évora and Porto in Portugal and Solana de los Barros in Spain. This situation will be compared at the end of the Project with the situation that will exist after two years of the prototypes implementation.

## 2. ENGLISH SUMMARY

This deliverable includes the different indicators selected for the evaluation of the impact of the Project's actions. The indicators have been organized by the environmental and social challenges faced by schools and social buildings as spaces present in urban environments.

For the indicators, the evaluation and calculation methodology and a description of the necessary monitoring are presented.

Once the indicators and their methodology have been collected, the study is presented as a baseline for the buildings that have been selected as demonstrators for the installation of the prototypes of nature-based solutions proposed in the project.

The analyses show the starting situation in the schools of Évora and Oporto in Portugal and Solana de los Barros in Spain. This situation will be compared at the end of the project with the situation in these schools two years after the implementation of the prototypes.

# 3. RESUMO EM PORTUGUÊS

This delivery includes the various indicators selected to evaluate the impact of the project's actions. The indicators were organized by the environmental and social challenges that schools and social centers face as spaces present in urban environments.

For the indicators, the evaluation and calculation methodology and a description of the necessary monitoring are presented.

Once the indicators and their methodology have been collected, the study is presented as a baseline for the buildings that were selected as demonstrators for the installation of the prototypes of nature-based solutions proposed in the project.

In the analyses, you can see the initial situation in the schools of Évora and Porto in Portugal and Solana de los Barros in Spain. This situation will be compared at the end of the project with the situation that exists two years after the implementation of the prototype.

# 4. INTRODUCTION

An important part of a demonstration project for the application of NBS (Nature Based Solutions) prototypes is the definition of an appropriate impact assessment scheme. For the definition of the impacts to be evaluated for the proposed action, the methodology of the European project EKLIPSE (http://www.eklipse-mechanism.eu/) has been used as a basis, but adapted to the demonstration proposed in LIFE myBUILDINGisGREEN. In this way, the chosen indicators will serve on the one hand to integrate the results obtained in databases at European level (such as the OPPLA platform (http://www.oppla.eu/) and also be comparable with other experiences that can be carried out in other projects.

The scheme chosen for this action is shown in Table 1. It includes the environmental and social challenges to be addressed with the proposed actions, the indicators that will allow us to see the impact of the actions and the metrics that have been considered appropriate for their evaluation.

*Table 1. Outline of the pre-established impact assessment methodology for LIFE myBUILDINGisGREEN.*

| ENVIRONMENTAL AND SOCIAL CHALLENGES | VARIABLES |
|---|---|
| Adaptation and mitigation CC | **Indoor building temperature**. Indicator related to the modification of the interior conditions of the building. Measured through temperature and humidity sensors inside the building. Four measurement points will be installed for each prototype building. One of the measurement points for each prototype will be installed in an annex or nearby building where no interventions will be carried out in order to have it as a reference. In addition, a weather station will be installed in each building.<br><br>**Building envelope temperature**. They will be measured using thermal images of the building envelopes before and after the interventions and taking references with pavement surfaces and nearby buildings.<br><br>**Outdoor environmental conditions of the building**. A weather station will be installed in each of the buildings if information is not available from any in the surrounding area.<br><br>**Modeling of the energy savings** produced by the solutions implemented if the same results were to be achieved with conventional refrigeration equipment. |

*Table 1. Outline of the pre-established impact assessment methodology for LIFE myBUILDINGisGREEN.*

| CHALLENGES ENVIRONMENTAL AND SOCIAL | VARIABLES |
|---|---|
| | **Estimated heating savings.** It will be calculated based on the energy consumption of the buildings before and after the interventions, taking into account the annual meteorological variations that may occur. |
| Water management | **Indicators related to water consumption** and savings that can be produced using the proposed BSS. They will be calculated using the water consumption data for irrigation of the current green areas in the locations of the prototype buildings.<br>**Indicators related to rainwater management savings.** The amount of rainwater collected with the roofs will be estimated. These quantities will also be calculated once the interventions have been carried out to determine the amount of water that is prevented from going to sanitation. |
| Management of green areas | **Increase in plant and animal biodiversity**. They will be evaluated according to protocols already established by the Royal Botanical Garden of Madrid, which will be transferred to the corresponding departments of each of the participating administrations or to users of the buildings that collaborate in the study.<br>**Number of native plant species recovered that are suitable (non-allergenic, non-poisonous, etc.) for integration into green areas.** |
| Air quality | **Noise reduction levels from outside**. To be determined by two annual campaigns at selected times.<br>**Number of bioindicator species installed** and area covered with these bioindicators.<br>Training in the observation of bioindicator species of pollution |
| Urban regeneration | **Energy efficiency measures.** Evaluation of existing energy efficiency measures before and after the actions.<br>**Increase in green area ($m^2$ and in %)**. Both in the area of action and in the rest of the population if the proposed solutions were extended. |

*Table 1. Outline of the pre-established impact assessment methodology for LIFE myBUILDINGisGREEN.*

| CHALLENGES ENVIRONMENTAL AND SOCIAL | VARIABLES |
|---|---|
| Governance and participation | **Citizen perception of urban nature**. Monitoring by conducting surveys to users of the monitored buildings and to citizens in general of the towns in which they are located.<br>**Learning policies and strategic plans for adaptation to CC**. Monitoring of participation in the events that take place.<br>**Open participatory processes. Monitoring of citizen participation in the open processes of definition of the recreational area. / park to be installed.** For all indicators that need to collect the opinions of citizens, surveys and interviews will be designed to collect information from stakeholders. |
| Social cohesion | **Number of agreements and disagreements**. Evaluation of citizen participation tools in the project. Measurement of the number of agreements reached with the different target groups and stakeholders versus the number of disagreements and establishment of a minimum limit as a target value. |
| Public health and welfare | **Reduction in the number of absences and absenteeism of students and teachers**. Calculation of this indicator using available historical data and those recorded after the interventions. |
| Economic opportunities and employment | **Number of jobs created**. Calculation of direct and indirect jobs created. Information to be collected by the administrations through the mechanisms available to them.<br>**Creation of new capacities in self-employed people and companies in the area related to the NBS**. Evaluation of capacities through surveys before and at the end of the project, once all the actions have been carried out, including dissemination and training in the areas of influence.<br>**Reduction of absenteeism among school personnel**. Direct measure. |

# 5. INDICATORS

This section will describe the indicators to be used in the definition of the baseline, categorized by the environmental and social challenges to which they correspond.

## 5.1 Climate change adaptation and mitigation

There is no doubt that climate change and global warming are the main environmental challenges and threats facing the world over the last decade.

The third assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2001) states that the global warming that has occurred over the last 50 years is due to anthropogenic factors. The increase in the concentration of greenhouse gases, especially carbon dioxide, has caused global warming. The change in atmospheric composition will continue during the 21st century accelerating the global climate change already underway.

Climate Change is increasing the frequency and intensity of droughts, floods and severe storms worldwide (Global Risks Report, 2016). In other words, the atmosphere and oceans have warmed due to human influence on climate systems, changes in the water cycle as well as reductions in the amount of snow and ice, average ocean levels and other extreme weather events (IPPC, 2013).

In Europe, some of the observed changes have set records in recent years. Europe has experienced the highest quality decade since temperature records have been kept. Human influence (mainly GHG emissions) together with changes in land use have been the main causes of the observed warming since the last half of the 20th century (IPPC, 2013). For example, mean annual temperature and the frequency and duration of heat waves have increased since the latter half of the 20th century. Precipitation has generally increased in northern and northwestern Europe while it has decreased in the southeast. Snow cover has been decreasing and permafrost has been warming. The frequency and intensity of extreme temperature and rainfall events are expected to increase in the coming years (IPPC, 2013; EEA, 2012).

Climate resilience is based on two interrelated concepts: "Adaptation", the ability to react and respond to stimuli or stresses generated by climate change, and "Mitigation" is the potential to improve the current state of an effect through active or passive behavior, specifically by reducing emissions or sequestering carbon dioxide (Van Vuuren et al., 2011; Calfapietra et al., 2015). Mitigation actions can be at the micro-scale such as a single building, at the meso-scale such as actions at the city or country scale, or at the macro-scale such as actions at the level of the entire planet (Raymond et al. 2017).

If climate mitigation and adaptation measures fail, more adverse extreme weather events, natural catastrophes, food crises, water crises, biodiversity loss and ecosystem collapse will occur. Moreover, this will lead to a chain reaction that will affect many other sectors as well (Global Risks Report, 2016).

LIFE myBUILDINGisGREEN advocates the creation of solutions that allow schools and social buildings to adapt to climate change, mainly seeking comfort for their users. In this regard, thermal comfort is the most important and most affected by the effects of climate change in southern Europe. The high temperatures in the late spring and early summer mean that currently the temperatures suffered both indoors and outdoors are excessive. The indicators selected to assess the impact of the proposed prototype actions are as follows:

***INDICATORS***

**I1.1 Indoor building temperature**. Indicator related to the modification of the interior conditions of the building. Measured through temperature and humidity sensors inside the building. The relative humidity measurement has also been included because it is a variable that can condition the thermal sensation of the users.

To determine the temperature in schools, several classrooms are selected and one sensor per classroom is installed. The classrooms are selected to cover the main orientations of the building (main insolation and shade).

In order to evaluate the impact of the actions, it is convenient to have reference values on the evolution of temperatures in locations unaffected by the proposed interventions. These references can be located in the same building in areas without intervention or in nearby buildings with similar characteristics.

Average daily, weekly, monthly and annual temperature values will be calculated for each classroom. Then the average values before and after the interventions in both prototype and reference areas are compared.

Calculations should be made using comparable time periods before and after the interventions (for a period before the interventions Nov19-Jun20, a period of Nov20-Jun21 and Nov21-Jun22 should be used).

The calculated values will be compared qualitatively and quantitatively before and after the interventions. The quantitative analysis will be performed using the following expression:

*Equation 1. Formula for **Temperature impact**.*

$$\textbf{\textit{Temperature impact}} = \left(\frac{NBS\ Temp.\ average\ after\ intervent.\ \text{-}NBS\ Expected\ Temp.\ average\ after\ intervent.}{NBS\ Expected\ Temp.\ average\ afteer\ intervent.}\right) \times 100$$

Where *temperatures average after intervent.* is the average value of the measurements after the interventions and *Expected temperature value after intervent.* (assuming that the interventions have not been performed) is calculated:

*Equation 2. Formula for* ***Temperature Expected average after intervent.***

$$\boldsymbol{Temperature\ Expected\ average\ after\ intervent.} = \left(\frac{Ref.\ Teemp.\ average\ afteer\ intervent.}{Ref.\ Teemp.\ average\ beefore\ intervent.}\right) \times NBS\ Temp.\ average\ beefore\ intervent.$$

The evaluation of the relative humidity of the air would be done using the same equations but the interpretation of the results will be made according to the time of the year and the temperature values reached. The objective will be to maintain the humidity in the range defined as adequate, between 30 and 70% (NPT 501, INSST).

**I1.2 Building envelope temperature**. They will be measured using thermal images of the building envelopes before and after the interventions and taking references with surfaces of the building itself without intervention, of pavements or nearby buildings.

This qualitative indicator will serve to visually show the impact of the interventions on the building envelopes. At least once before the interventions and preferably one day with high insolation and high temperatures and another one after with the same conditions, a photographic report of thermal images will be taken of each school and a nearby building with characteristics as similar as possible in terms of orientation, materials and color.

The analysis of this indicator will be used primarily for communication and awareness of the impact on temperature in buildings. It will not be used to quantitatively analyze any impact.


*Comparison between the surface temperatures of a green roof and a concrete roof (U.S.EPA, 2008).*

**I1.3 Environmental conditions outside the building**. The environmental conditions on the exterior of buildings can be modified by the implementation of NBS. Both temperature and ambient humidity in the vicinity of the envelope will be used as an indicator of the impact of the project actions. The monitoring of this indicator is done by means of relative air humidity and temperature meters on the two main facades of the building, which will be used to implement the natural ventilation measures.

For the quantitative analysis of the impact, the same methodology described for the **indoor temperature** indicator of **the building** will be used, using formulas 1 and 2.

**I1.4 Modeling of the energy savings produced** by the solutions implemented if the same results were to be achieved with conventional refrigeration equipment.

For this purpose, depending on the temperature reduction achieved with the measures implemented, the energy consumption of a commercial refrigeration unit installed in each classroom will be calculated.

The energy simulation program *Design Builder* (version 4.3) is used to calculate this indicator. This software incorporates *Energy Plus* (University of California) as the calculation engine and allows dynamic analysis of energy behavior. The results can be studied on an annual scale, or down to daily behaviors with intervals of up to half an hour. It allows, therefore, to estimate indoor temperatures, energy demands according to setpoint temperatures, or energy consumption according to systems. All this applied to the months of interest.

The relevant parameters included in the model are:

- The geometry of the building with its partitions, orientations, façade openings, etc.

- Construction systems of the envelope and interior partitions. With their thermal properties of interest such as resistance, reflectance, optical properties, specific heat, conductivity, etc.

- Airtightness and ventilation conditions.

- Activity use patterns. Window openings, grilles, slogan times.

- The systems that provide the energy needed to reach comfort temperatures.

The *software* makes use of *solvers* for the calculation of the differential equations of energy balances:

*Equation 3. Model equation to predict energy consumption for refrigeration.*

$$C_z\frac{dT_z}{dt} = \sum_{i=1}^{N_{sl}} \dot{Q}_i + \sum_{i=1}^{N_{surfaces}} h_i A_i \left(T_{si} - T_z\right) + \sum_{i=1}^{N_{zones}} \dot{m}_i C_p \left(T_{zi} - T_z\right) + \dot{m}_{\inf} C_p \left(T_\infty - T_z\right) + \dot{Q}_{sys}$$

Where:

$\sum_{i=1}^{N_{sl}} \dot{Q}_i$ = sum of the convective internal loads

$\sum_{i=1}^{N_{surfaces}} h_i A_i \left(T_{si} - T_z\right)$ = convective heat transfer from the zone surfaces

$\dot{m}_{\inf} C_p \left(T_\infty - T_z\right)$ = heat transfer due to infiltration of outside air

$\sum_{i=1}^{N_{zones}} \dot{m}_i C_p \left(T_{zi} - T_z\right)$ = heat transfer due to interzone air mixing

$\dot{Q}_{sys}$ = air systems output

$C_z\frac{dT_z}{dt}$ =energy stored in zone air

$C_z = \rho_{air} C_p C_T$

$\rho_{air}$ = zone air density

$C_p$ = zone air specific heat

$C_T$ = sensible heat capacity multiplier (Detailed description is provided below)

The study of the energy saving capabilities of the NBS solutions is carried out on the basis of a calibrated model with on-site monitoring in the pilot buildings. The characteristics provided by the NBS in the different actions are modified, and the consumption results are compared with the initial model and the current situation.

**I1.5 Estimated heating savings**. It will be calculated based on the energy consumption of the buildings before and after the interventions, taking into account the annual meteorological variations that may occur.

This indicator will be calculated using actual annual fuel consumption data for each building. To select the baseline value, the average value for the last 10 years of the school's activity shall be used, if sufficient data is available.

Apart from the building envelope conditions themselves, other parameters such as outdoor temperatures or the management of the heating system can affect consumption. For

To estimate the impact, the temperature profile during the winter months will also be studied.

## 5.2 Water management

Climate change will negatively impact the quantity and quality of water available globally to meet a range of basic human needs, undermining the fundamental right of billions of people to have access to safe drinking water and sanitation.

The deterioration of the world's water resources jeopardizes the achievement of Sustainable Development Goal (SDG) No. 6 of the United Nations 2030 Agenda, which aims to achieve access to clean water and sanitation for all within the next ten years. This is a very considerable challenge, given that there are currently 2.2 billion people in the world deprived of access to safe drinking water and another 4.2 billion lacking safe sanitation systems. (UNESCO, UN-Water, 2020).

World water consumption has increased sixfold in the last 100 years and continues to grow at an annual rate of 1%. Climate change and the resulting increase in extreme weather events, such as droughts, floods and storms, will aggravate the situation in countries already suffering from "water stress" and also in regions of the world that are so far well supplied with water (UNESCO, UN-Water, 2020).

With increasing evidence of ongoing meteorological and hydrological changes (Blöschl et al., 2017; Su et al., 2018) and projections of substantial increases in these changes in the near future, the urgency for adaptation in water management is insurmountable. Without concrete adaptation measures, water scarcity, both in terms of surface and groundwater resources, is expected to expand to some regions where it does not currently exist and to worsen significantly in many regions where water resources are already stressed (Gosling and Arnell, 2016 )

Beyond the adoption of urgently needed adaptation measures to increase the resilience of the water system, improved water management opens up opportunities for climate change mitigation and adaptation. Mitigation measures such as water reuse, conservation agriculture, and renewable energy (hydropower, biofuels, wind, solar, and geothermal) can directly affect water resources (e.g., by increasing or decreasing water demand), and it is important to recognize these two factors: way relationship when developing and evaluating mitigation options (Wallis et al., 2014).

Water management within the LIFE myBUILDINGisGREEN project will be one of the main axes in terms of the impact that the implementation of the BSS can have on it. In order to assess the impact of the interventions on water management, the following will be taken into account two main indicators: with two main indicators: savings in water consumption in used in irrigation water for the pilot buildings and savings in rainwater management.

***INDICATORS***

**I2.1 Savings in water consumption for irrigation of green areas in the pilot buildings.** The savings that can be produced by using the proposed BSS will be calculated. They will be calculated using the water consumption data for irrigation of the current green areas in the locations of the prototype buildings. The amount of water consumed (m3) in the green areas of the pilot buildings before and after the application of the proposed BSS will be calculated.

**I2.2 Savings in rainwater management**. The amount of rainwater collected with the roofs and other NBS implemented will be estimated. The amount of water that the implemented NBS will accumulate and thus avoid entering the wastewater treatment system will be calculated. Rainfall avoided to the sewage system (in m3, €, etc. depending on available information).

For the calculation of rainwater going to the sewer for each type of solution, the volume of runoff water produced under given conditions is calculated. The following equation is used:

$$Q = \begin{cases} (P - I_a)^2/(P - I_a + S), & P \geq I_a \\ 0, & P < I_a \end{cases}$$

$$S = \frac{25,400}{CN} - 254$$

$$I_a = \lambda \cdot S$$

Where:

- Q: the runoff height (mm). It is the way of expressing the volume of water collected per unit area.
- P: The amount of fallen water (mm). As in the previous case, it is expressed in height of water per unit area.
- $I_a$: The initial uptake (mm). This is the water that is not converted to runoff by evaporation, absorption on surfaces, etc.
- S: The maximum water absorption capacity of the soil.
- λ: The initial uptake coefficient, which is a constant, usually defined as 0.2 (*El-Hames, 2012; Kadam et al., 2012; Singh et al., 2013*).

- NC: Dimensionless parameter between 0 and 100. The National Conservation Service (NCRS) has developed NC values for various land cover types based on their hydrological characteristics.

## 5.3 Management of green areas

Cities are high emitters of greenhouse gases and are drivers of environmental modification, often leading to the degradation and fragmentation of ecosystems at local and regional scales. Linked to these trends is a growing threat experienced by urban areas: the risk of hydrometeorological and climatological hazards, further accentuated by climate change. Ecosystems, although often overlooked or degraded, can provide multiple risk-regulating functions, such as coastal and surface flood regulation, temperature regulation, and erosion control.

Currently, the growth of cities and climate change are increasingly affecting the world's land area and health creating a number of challenges for urban planning. The global urban population is expected to increase by more than two-thirds by 2050, from 3.9 billion in 2014 to 6.3 billion in 2050 (United Nations, Department of Economic and Social Affairs, 2014). The interrelated pressures of land conversion, densification of built-up areas, declining quantity of and access to urban green and blue spaces, increased traffic, and the related effects of air and noise pollution pose significant threats to human health and well-being. In addition, climate change will have a significant impact on city environments. The main effects of climate change in cities include **increased air temperature** (e.g. during heat waves), **poor air quality** and **increased ozone concentration**, as well as **extreme precipitation events** (European Environment Agency 2011).

Adaptation of cities is becoming one of the biggest challenges facing urban planners in this century. Urban green infrastructure (GI) could help cities adapt to climate change, and the strategy of expanding greening in urban planning could play an important role in improving the sustainability and resilience of cities and communities.

In the EU, the term GI was first introduced in the commission's 2009 white paper, "Adapting to Climate Change" (EU, 2009) Throughout EU legislation, the term "Green Infrastructure" is used in relation to landscape resources, with particular emphasis on ecological connectivity. In contrast, the European Environment Agency (EEA) and other European programs choose to use the term "green spaces", "green systems" or "green infrastructure".

"green structure" when referring to the urban environment or other related issues (EEA, 2011; Werguin et al, 2005).

The objectives of the EU IG strategy (EU, 2013) are:

-To enhance, conserve and restore biodiversity by, among other things, increasing spatial and functional connectivity between natural and semi-natural areas and improving landscape permeability and mitigating fragmentation.

Maintain, strengthen and, where appropriate, restore well-functioning ecosystems to ensure the delivery of multiple ecosystem and cultural services.

-Recognize the economic value of ecosystem services and increase the value in itself, strengthening its functionality.

-Improve the social and cultural link with nature and biodiversity, recognize and enhance the economic value of ecosystem services, and create incentives for local stakeholders and communities to provide them.

-To minimize urban sprawl and its negative effects on biodiversity, ecosystem services and human living conditions.

-To mitigate and adapt to climate change, mitigating urban heat islands.

-To contribute to healthy living, better places to live, providing open space and recreational opportunities, increasing urban-rural connections, contributing to sustainable transportation systems and strengthening the sense of community.

The LIFE myBUILDINGisGREEN project aims to contribute to the development of green space management solutions to improve the quality of comfort of the users of the pilot buildings, mitigating the effects of heat waves caused by climate change. It is also expected that the implementation of these solutions will favor the biodiversity of the environment where the pilots are developed, increasing the number of plant species present, as well as the animal species associated with them.

***INDICATORS***

**I3.1Increase in plant and animal biodiversity**. They will be evaluated according to protocols already established by the Royal Botanical Garden of Madrid, which will be transferred to the corresponding departments of each of the participating administrations or to users of the buildings collaborating in the study.

**I3.2 Number of native plant species** recovered that are suitable (non-allergenic, non-poisonous, etc.) for integration into green areas.

## 5.4 Air quality

Air quality is a worldwide concern, particularly in urban areas, due to its direct consequences on the health of people, animals, plants, infrastructure or historic buildings, among others.

Air pollution is both a local and transnational problem. A pollutant emitted in one country or continent can be transported to another contributing to or causing air quality problems elsewhere.

Particulate matter, nitrogen dioxide and ground-level ozone are currently the three most significant pollutants affecting human health. Both long-term and peak exposures of these pollutants vary in severity of impact, from altering the respiratory system to premature death. About 90% of Europe's urban dwellers are exposed to pollutants at concentrations higher than recommended levels. For example, it has been estimated that fine particulate matter (PM2.5) in the air reduces life expectancy in the EU by more than eight months. European Union legislation sets both short-term (hourly/daily) and long-term (annual) air quality standards (Directive 2008/50/EU).

Air pollution also damages our environment. Problems such as acidification were substantially reduced between 1990 and 2010 in sensitive areas of Europe's ecosystems that were subjected to acid deposition of excess sulfur and nitrogen compounds. Reductions due to emission control of some parameters and control of the quality of fuels used. However, less progress was made on other environmental issues such as high ozone concentrations that cause damage to crops and vegetation in general. Most agricultural crops are exposed to ozone levels that exceed the EU's long-term objective to protect vegetation. This notably includes a significant proportion of agricultural areas, particularly in southern, central and eastern Europe.

There are several sources of air pollution, both anthropogenic and natural.

- Combustion of fossil fuels for electricity generation, transportation, industry and households;
- Industrial processes and solvent use, e.g. in chemical and mining industries;
- Agriculture;
- Waste treatment;
- Volcanic eruptions, windblown dust, marine aerosols and emissions of volatile organic compounds from vegetation.

However, the impact of NBS on air quality in cities is limited in most circumstances. Studies show that once pollution is emitted it is much more difficult to try to capture it efficiently afterwards. Placing vegetative barriers along high traffic areas and close to the emission may be a way to capture particulate matter to some extent but not enough to minimize the problem. On the other hand, it can also be interesting to install vegetation barriers around schools or hospitals but doing previous studies of pollutant dispersion (Baró et al., 2015; Alseki et al., 2016).

On the other hand, it is also important to consider indoor air quality, which can also affect the health, comfort and well-being of building occupants. Poor indoor air quality is linked to sick building syndrome, lower productivity and poorer learning in schools.

Poor indoor air quality can be due to gases (including carbon monoxide, radon, volatile organic compounds and carbon dioxide among others), particulates, microbial contaminants (bacteria and fungi), viruses or radiation, among other agents. Control of emission sources, air filtration or ventilation to dilute pollutants are the first methods to be applied to improve indoor air quality.

Indoor air quality can be determined by collecting air samples, monitoring human exposure to pollutants, collecting samples on surfaces or modeling indoor flows. Another way is to use continuous meters for compounds that can be considered tracers of indoor air quality and that can even affect human health at high concentrations such as carbon dioxide, $CO_2$.

Although the concentration of $CO_2$ in the atmosphere is around 400 ppm, a large group of studies can be found in the literature in which the concentration is higher than 1000ppm and in some cases even reaches 4000ppm. These studies suggest that poor ventilation can result in high exposure to indoor air pollutants causing health problems and lack of concentration among other effects (Muscatiello et al., 2015).

Another type of air pollution is noise. This project has chosen to include this pollutant in this challenge but it is also sometimes included in the public health and welfare category.

Some NBS have the ability to reduce noise levels or combine with other elements to generate noise barrier elements.

The LIFE myBUILDINGisGREEN project seeks to evaluate the impact of the proposed prototype NBS on the indoor air quality of classrooms as a way to increase the comfort and health of building users. Therefore, CO2 concentration has been proposed as the main indicator. On the other hand, an indicator has also been included to assess the impact of the solutions on the acoustic insulation capacity of the interior of the classrooms. Finally, two indicators have been included on the use of bioindicator species of pollution outside the school, mainly for awareness-raising purposes.

***INDICATORS***

**I4.1 Indoor carbon dioxide concentration.** The concentration of carbon dioxide ($CO_2$) inside the classroom is an indicator of the quality of the indoor air in the classroom and the level of ventilation in the classroom. These values will be used to define and evaluate the effectiveness of natural ventilation measures.

To determine this indicator, $CO_2$ sensors are installed in the classrooms; one per classroom is sufficient.

To evaluate this indicator, the number of hours per year with concentration values above the recommended limits (1000ppm) before and after the interventions will be measured. The reference classrooms without application of the measures will be used to take into account the influence of other possible factors.

**I4.2 Noise reduction levels from outside**. To be determined by two annual campaigns at selected times.

A standard source of noise emitted from the outside will be used for measurements, and with the windows closed, measurements will be taken from inside the classrooms before and after the interventions. In addition, a reference measurement will be taken in a place not affected by the interventions carried out.

The method presented is only intended to provide an approximate value of the degree of noise attenuation that can be provided by the proposed prototype interventions.

The measures will be carried out at times when the school is empty.

To evaluate the results, the quotient of the values recorded before and after the interventions will be made using the values of the reference site to assess the impact of the actions.

**I4.3 Number of bioindicator species** installed and area covered with these bioindicators.

**I4.4 Training in the observation of bioindicator species of contamination**.

## 5.5 Urban regeneration

The enormous growth of urbanization since the middle of the 20th century and its effects on the environment and on people's quality of life have focused, in recent years, the attention of public policies and actions with an impact on the urban environment. The spectacular increase in the world population, coupled with the aforementioned urban development, has led to a long list of problems whose magnitude threatens the balance of the planet and the forms of human life as we know them (Instituto Valenciano Edificación, 2015).

In fact, evidence of climate change, mainly caused by greenhouse gas emissions, has highlighted the imbalances caused by a system where cities consume about 70% of the planet's resources (Fischer- Kowalsky M. et al., 2011).

The main symptoms of this intensive urbanization phenomenon can be summarized in two broad categories: effects on the environment and on people.

Cities, and therefore the urban way of life developed in them, are considered to be responsible for 75% of greenhouse gas emissions (Michele A., 2012). As for the effects on people, this phenomenon of urban hyper-growth, together with changes in social patterns and structures, has led to increasing public health problems, greater concern for safety, phenomena of social exclusion for reasons of age or gender, etc.

The global nature and the growing seriousness of the problem have led to the urgency of activating mechanisms that, at all levels, reverse the trend in which we still find ourselves today.

Faced with the requirement to constantly adapt the physical support of the city to growing and changing demands of urban activities and uses, the European Union pointed to the need to "promote settlement patterns that use resources efficiently, limiting land use and urban sprawl", rightly among its objectives for the improvement of urban environments (UN-HABITAT, 2013).

These reflections reinforce the idea of boosting policies and tools that, by promoting urban regeneration actions, help to build the path towards new resilient urban models, facilitating the transition towards low carbon and low resource consumption economies, as can be seen in the commitments adopted in the Leipzig Charter on Sustainable European Cities in 2007 or in the Europe 2020 Strategy. (Instituto Valenciano Edificación, 2015).

Contributing to the improvement of spaces and environments through the solutions implemented in the LIFE MyBuildingisGREEN pilots will make it possible to objectively assess whether the solutions implemented in the LIFE MyBuildingisGREEN pilots have been successful.

The solutions implemented have a direct effect on new, more sustainable building models and lower energy consumption.

***INDICATORS***

**I5.1 Energy efficiency measures**. Evaluation of existing energy efficiency measures before and after the actions. To evaluate this indicator, a list of energy efficiency measures implemented in the building during the implementation of the project will be made. In addition, the amount of energy consumed per unit area before and after the actions will be calculated. This calculation will be disaggregated into two values, the energy consumed as heating fuel and the energy consumed as electricity.

**I5.2 Increase in green area (**$m^2$ and in %). Both in the area of action and in the rest of the population if the proposed solutions were extended.

The $m^2$ of green areas before and after the actions, on the pilots and on the rest of the population if these actions are replicated, will be quantified.

## 5.6 Governance and participation

Governance refers to a system of social coordination to solve common problems and achieve common goals (Rhodes et al., 1996). Simply put, governance could be said to be about what is done, why it is done, who does it, and how it is done (Borrini- Feyerabend et al., 2013). The term governance is used because the decision-making process and required actions are needed beyond the government itself. The inclusion and active participation of a wide range of stakeholders is essential to resolve the systemic nature of the challenge.

In collaborative governance, the formal institutions of government provide not only the hard infrastructure of the planning system, but also a soft form of infrastructure called "relationship building". This soft infrastructure is the locally specific space where social, political and intellectual capital is formed. Collaborative planning is central to the particular form of governance that is best suited to implement NBS, called collaborative governance. Collaboration is born of practical necessity, as ecological features and processes cross jurisdictional boundaries, scales, tenures, economic sectors and political portfolios. Authority, capacity, and responsibility for NBS implementation, therefore, do not rest with a single central entity and, consequently, achieving objectives requires the participation of multiple stakeholders (Kark et al., 2015; Clement et al., 2016; Nelson et al., 2006). Participatory planning and governance increasingly embrace broader changes in the way society addresses environmental challenges. Top-down regulatory and command-and-control approaches and control are increasingly replaced by partnerships and the preferential use of non-regulatory approaches, such as market-based instruments, volunteering and education, often implemented through collaborative partnerships (Gunningham, N., 2009).

This challenge includes governance and planning because the two work hand in hand. Planning is an important part of governance because it injects a long-term strategic vision into governance and provides a space for actors to think and act collectively on problems (Healey, P., 2006).

Strategic planning in particular is important for NBS to be effective. In the collaborative planning model, planning is done through a series of face-to-face dialogues between experts and stakeholders, i.e., actors interested in the available outcomes (Innes & Booher, 2003).

Due to the special characteristics of the typology of the buildings chosen (schools and social buildings) for the installation of prototypes, in the LIFE myBUILDINGisGREEN project it has been considered basic to install the dialogue between the different stakeholders, both in the collection of the needs of the buildings and in the definition of the most appropriate solutions, how to implement them and also to involve the users themselves in the maintenance and sustainability of the same. This has led to modifications being proposed to the initial designs of the prototypes to be implemented, but has led to greater user acceptance and satisfaction.

The indicators selected are intended to reflect these impacts.

***INDICATORS***

**I6.1 Citizen perception of urban nature**. Monitoring through surveys of users of the monitored buildings and citizens in general of the towns in which they are located.

Prior to the implementation of the actions, a survey will be carried out among the users of the pilot buildings where they will value

**I6.2 Learning policies and strategic plans for adaptation to CC**. Monitoring of participation in the events that take place.

A database will be created to anonymously collect the number of participants per event held during the execution of the project.

**I6.3 Open participatory processes**. Monitoring of citizen participation in the open processes of defining the recreation area / park to be installed. For all indicators that need to collect the opinions of citizens, surveys and interviews will be designed to collect information from stakeholders.

## 5.7 Social cohesion

The development of a project where its interventions have direct implications on citizens should be designed in a way that supports both social justice and social cohesion (Haase, D., et al.2017 ; Wolch, J.R, et al 2014). The same has to apply for citizen participation processes involving the development of NBS.(Buijs et al .2017; Mattijssen et al 2017).

The development of LIFE myBUILDINGisGREEN has to count on the performance of its activities supporting social cohesion in the environments where the pilots are developed, in different aspects that include:

- Creation of public spaces that encourage recreation, such as green areas and urban landscapes. This is associated with meeting or observing people of different cultures, income, age, gender, ability, sexuality, etc. (Peters K, et al. 2009).
- Create spaces or features that contribute to a municipality's shared identity, such as iconic parks and squares, wooded areas or gardens that can create identity.

Social justice is an important consideration when performing NBS implementation actions, for a few reasons, as it can be positive but not necessarily fair or inclusive.(Haase, D., et al.2017).

It is important to work with awareness of the following realities that apply to most cities:

- NBS and its associated services in cities are not evenly distributed in space, and some areas will have a greater need.
- NBS in cities are not equally accessible or welcoming to all people.
- Maintenance of existing NBSs is not equally distributed.
- NBS selection and design processes are not always equally inclusive, nor are all opinions of the participants in these processes treated equally.
- New NBS projects do not always benefit everyone equally.

It is important that the design of the actions, their implementation and the consultation with the agents involved in the project are carried out in a way that includes all the people involved in terms of age, gender, culture, income, etc.

***INDICATORS***

**I7.1 Number of agreements and disagreements**. Evaluation of the tools for citizen participation in the project. Measurement of the number of agreements reached with the different target groups.

and stakeholders versus the number of disagreements and establishment of a minimum limit as a target value.

## 5.8 Public health and welfare

There are many pressing public health and environmental challenges associated with modern life, with rapidly increasing levels of chronic non-communicable physical and mental health conditions (Moore et al., 2003) and global recognition of the serious health risks posed by stressful living conditions (Schneiderman et al., 2005). Engagement with nature is a common pursuit in cities (Cox et al., 2016)] and is increasingly recognized as a means to alleviate many of these challenges.

Evidence now points to benefits for physical health (e.g., lower prevalence of high blood pressure and allergies, Donovan et al., 2018; Shanahan et al., 2016), mental health (e.g., lower prevalence of depression and anxiety, Shanahan et al., 2016; Cohen-Cline et al., 2015; Pretty et al., 2007), and social well-being for people who spend time in nature. Furthermore, there is evidence that the magnitude of such benefits may increase with nature dose (Cohen-Cline et al., 2015). Therefore, it is of great concern that urbanization and the challenges of modern life are leading to reduced engagement with the natural environment (Soga et al., 2016).

To counter this development, nature-based health solutions (NBS) can facilitate change through a somewhat structured promotion of nature-based experiences. These solutions will develop programs, activities, or strategies that aim to engage people in nature-based experiences with the specific goal of achieving better health and wellness. For example, environmental manipulations in which green and blue spaces are incorporated into cities can have positive outcomes associated with habitat management and the flow of ecosystem services to people but there is also a growing body of evidence highlighting the potential of green space for the treatment and prevention of physical, mental, and social health and wellness challenges (Shanahan et al., 2019)

This recognition that experiences of nature can provide benefits for people represents an important shift in public health thinking for both prevention and treatment of health problems, beyond considering nature solely as a risk factor (e.g., through transmission of insect-borne diseases (Douglas et al., 2012; Frumkin et al., 2001; Husk et al., 2016; Finlayson et al., 2015)

The implementation of the measures on the pilots in the LIFE myBUILDINGisGREEN project will directly affect a very vulnerable sector of the population, such as the school population, so the analysis that these measures have on their health and that of other users involved is of special interest.

*INDICATORS*

**I8.1 Reduction in the number of absences and absenteeism of students and teachers**. Calculation of this indicator using available historical data and those recorded after the interventions.

## 5.9 Economic opportunities and employment

Climate change has significant impacts on ecosystem functioning, human well-being and the economy. In addition to climate change, urbanization increases interrelated pressures on the city, posing additional significant challenges to sustainable development and service provision in urban areas. However, NBSs have the potential to balance and minimize these pressures, taking into account the services provided by nature (Kabisch et al., 2017)

To date, an increasing number of NBS projects have been implemented. Consistent scientific evidence on the impacts of NBS in the process of climate change mitigation and adaptation has been widely presented through interdisciplinary approaches. These studies also include how NBS could be evaluated economically and how economic valuation and related concepts can provide a rationale for the introduction of NBS in cities (Kabisch et al., 2017)

For example, the green roof market in Germany, Switzerland and Austria is very mature and in these countries, a minimum of 10.3 Mm2 of green roofs are installed every year (Enzi et al., 2017).Outside these three main European markets, several other cities, such as London, Rotterdam and Paris, show a significant increase in the installation of NBS, such as green roofs. In addition, independent market research estimates that around 1 million $m^2$ of green walls were installed in 2017, representing an investment of €680 M (Enzi et al., 2017).

NBS represent an attractive investment and, in this context, the construction-related benefits of green infrastructure investments are crucial. Private investment is generally based on financial benefits, e.g., heating and cooling savings, increased energy efficiency, high property values, and extended lifetimes of building materials (Enzi et al., 2017; Van Ham et al., 2017; Wamsler et al., 2017). The private sector represents a valuable partner for implementing NBS, which has the potential to offer innovative solutions to urban challenges. This sector is able to provide ideas and perspectives, which are complementary to those of governments and civil society. Their specific knowledge of markets, management expertise and detailed advanced research can be valuable assets in the context of NBS implementation IUCN (2012).

Multi-stakeholder partnerships, civil society organizations, scientists and other urban stakeholders are crucial to highlight the value of NBS for sustainable urban development and economic prosperity (Van Ham et al., 2017).

Producing solid evidence on NBS for climate change adaptation and mitigation and raising awareness of their multiple benefits is critical to the development of new economic opportunities. NBS have the potential to facilitate cooperation between sectors and contribute to a more holistic approach to the development of green jobs. Citizen participation is also a crucial aspect of this process, as it enables the implementation of more effective environmental regimes that address societal challenges and needs.

***INDICATORS***

**I9.1 Number of jobs created**. Calculation of direct and indirect jobs created. To determine the number of direct jobs created, the companies awarded the works in the schools will be consulted on the number of jobs they have created for the execution of the works. In this way, the number of full working days generated will be known.

**I9.2 Creation of new capacities in self-employed and companies in the area** related to the NBS. Evaluation of capacities through surveys before and at the end of the project, once all the actions have been carried out, including dissemination and training in the areas of influence.

**I9.3 Reduction of absenteeism** among school staff. To evaluate this indicator, data on absenteeism at the schools before and after the interventions will be analyzed. A historical average value of the ten years prior to the intervention in the school will be taken and compared with the data from the years after the intervention.

The data will be received anonymously from the administrations only indicating the number and duration of the absences produced in the centers and, if possible, the reason.

# 6. BASELINE OF BUILDINGS

## 6.1 Evora

*INTRODUCTION*

Following the general objective of the project "to contribute to increase resilience in buildings through the implementation of Nature-Based Solutions as prototypes of climate adaptation and improvement of *well-being* in buildings", a series of actions are proposed in this building to improve the thermal comfort of the children and teachers of the school, propose appropriate ventilation formulas to improve indoor air quality, increase the amount of green areas in the school space in a sustainable way, reduce the carbon footprint of the buildings, improve water management in the buildings, recover and promote local biodiversity in the urban environment and raise awareness of the value of nature and the eco-systemic services that are produced.

In general, it is proposed to reduce the impact of solar radiation on the building envelope and prevent the entry of direct solar radiation through the openings, generate air circulation inside the building in summer with naturally "cooled" air, increase seasonal shaded areas on the outside of the buildings and install draining floors and other solutions to capture all rainwater and not divert it to the public sewage system.

In addition, the air renewal achieved with these actions should reduce carbon dioxide levels inside the classrooms and increase thermal comfort. This is an impact associated with the actions that will improve the health and well-being of students and teachers.

Finally, the involvement of students, faculty and the AMPA is considered crucial for this project to be integrated into the academic curriculum of the school, and to avoid loss of vegetation, transmitting to the students the benefit they will bring when the plantations are fully developed (5 years maximum). This action will make it possible to include many aspects of experimental subjects in the school's educational project, with the possibility of carrying out many activities in situ that will reinforce classroom content (pollinators in the area and their importance in plant production; increasing urban diversity associated with sustainable plans; experimentation in the cultivation of plants with potential for extensive cover in areas with extreme climates; variations in temperature and other parameters used in mathematics, for example; etc.).

First the climatic conditions of the area will be reviewed, then the characteristics of the building and finally a review of the status of the proposed impact assessment indicators will be carried out.

*LOCATION*

Escola EB1 Horta das Figueiras

Estrada das Alcáçovas

7005-206 Horta das Figueiras, Évora, Portugal

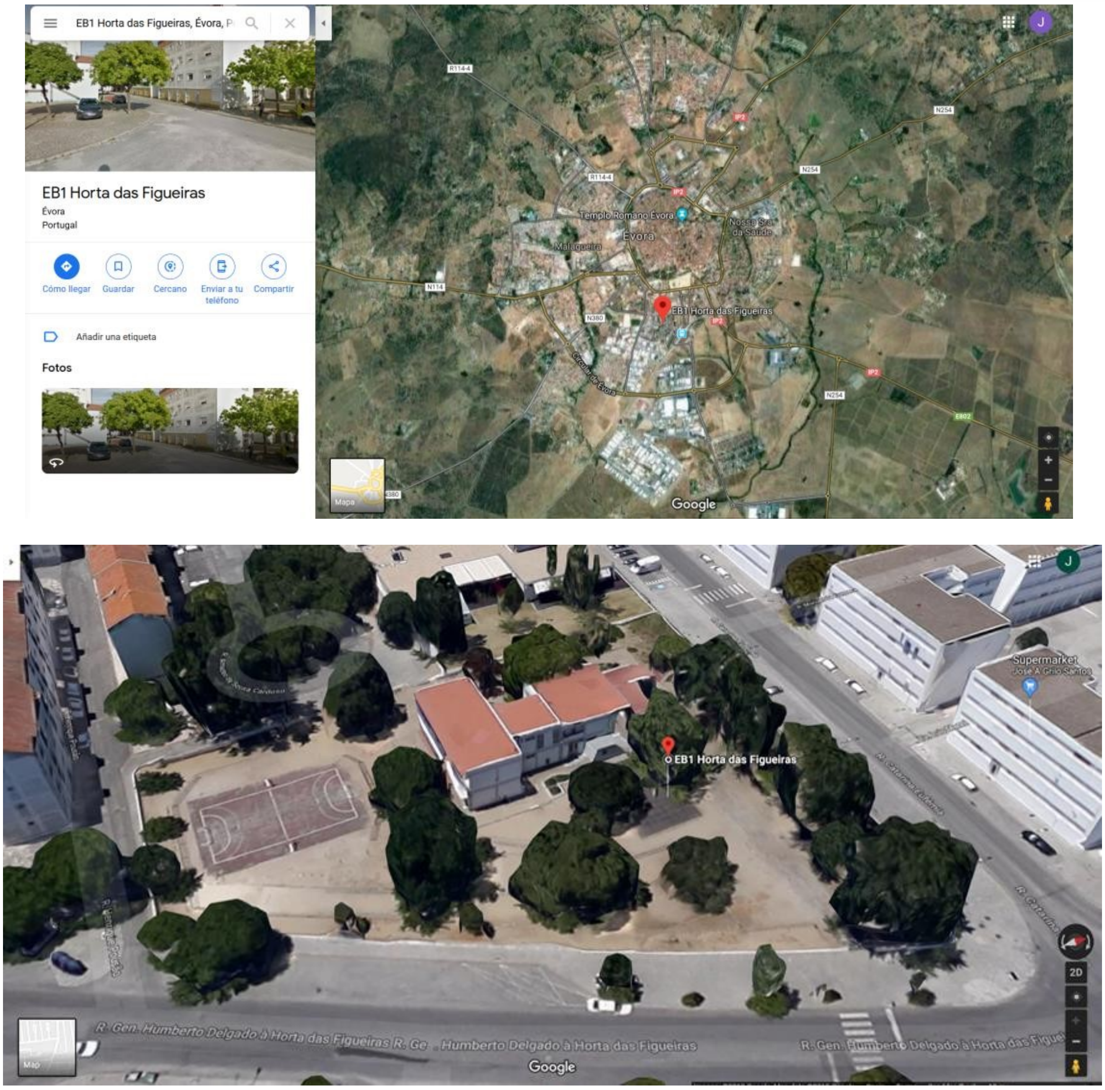




*Figure 2. Location of Escola EB1 Horta das Figeiras in Évora (Portugal).*

*CLIMATIC DATA*

Summers are short, very hot, dry and mostly clear. Winters are long, cold and partly cloudy. During the course of the year, the temperature generally varies from 5 °C to 33 °C and rarely drops below 1 °C or rises above 38 °C (https://es.weatherspark.com).

The hot season lasts 2.9 months, from June 18 to September 13, and the average daily maximum temperature is more than 29 °C (79 °F). The hottest day of the year is July 29, with an average maximum temperature of 33 °C and an average minimum temperature of 16 °C.

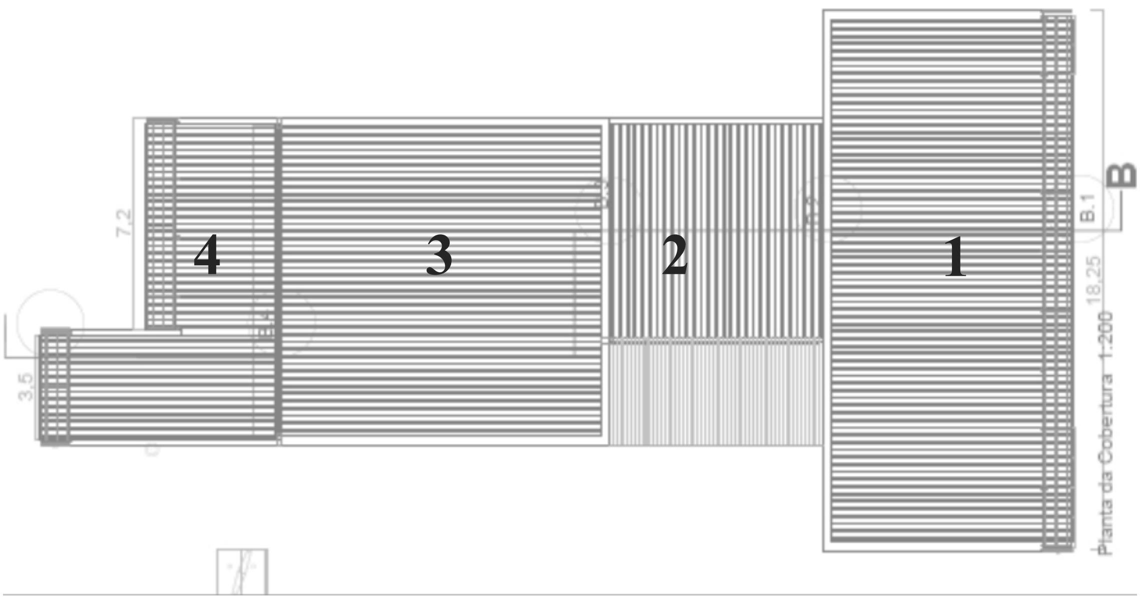
The cool season lasts 3.7 months, from November 15 to March 6, and the average daily maximum temperature is less than 17 °C. The coldest day of the year is January 18, with an average minimum temperature of 5 °C and an average maximum of 13 °C.

The average rainfall in Évora is 629 mm. The driest month is August, with 4 mm of rainfall. The highest amount of precipitation occurs between the months of November and February with more than 80 mm monthly average.

Complete climatic data for this location are presented in Annex I.

*BUILDING DESCRIPTION*

There are 4 roof areas that were initially finished with fiber cement sheeting and are now encapsulated with modular panels.



The initial letter of the orientation (N, S, E and W) and the number of the roof to which it corresponds according to the previous scheme will be used as coding.



**North elevation**


**South façade**

**Deck 1.**

Deck 1 covers classrooms 3, 4 and art education so it would have direct impact on these classrooms which are located on level 1. No current access and low visual impact (visible only from nearby tall buildings).

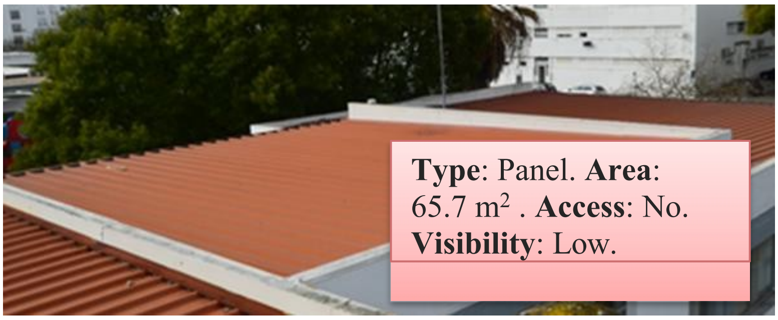
**Type**: Panel. **Area**: 154.5 m$^2$ . **Access**: No. **Visibility**: Low.

**Monitoring**

Two sensors ($CO_2$, T and RH) have been instal ns.

**Deck 2.**

Deck 2 covers the lobby and restrooms on level 1. These are pass-through spaces with low use. No current access and low visual impact (visible only from nearby tall buildings).




**Deck 3.**

Deck 3 covers a space on the dining room/multipurpose room on level 1. Deck with no current access and low visual impact (visible only from nearby tall buildings).


**Monitoring**

A sensor ($CO_2$, T and RH) has been installed in this space.

**Deck 4.**

Deck 4 covers the unoccupied office space on level 1 on the first floor.

## South façade

The south façade is the one that receives the most sunlight in the school and is where the main classroom windows are located. Currently there is a tree that partially shades the area of the east corner of this façade. There are several possibilities for this façade.

In front of the facade there are two large planters that currently house shrubs.

**Number**: 9 windows and door **Room**: Classrooms and bathrooms. **Length**:

Next there is an area that communicates with the sports court that has a slight slope and where the tree that shades the east corner of the facade is planted. Perimetrically there is a small channel that collects rainwater and has inlets (it seems to be) to evacuate it to the city's sewage system.

## Monitoring

Four sensors ($CO_2$, T and RH) have been installed in the four classrooms on the façade, two on the first floor and two on the upper floor.

## East façade

**Number**: 7 vent. and door **Stay**: Common y auxiliary

The east façade is the one that receives the most sunlight in the morning hours. It is partially shaded by trees. As openings it has small windows to bathrooms, windows to the staircase area, a window to the multipurpose room and a door.

## Monitoring

An exterior east façade sensor (T and RH) has been installed to implement the natural induced ventilation formulas.

**West façade**

The west façade is the one with the main entrance to the school and has a covered area before the main door. This area can be used as a fresh air entrance area in the morning. The windows to the multipurpose room are also located on this façade, but these are already shaded by the existing tree.

The O1 façade located in the entrance area creates an aesthetic impact that can be naturalized.

**Number**: 2 windows. **Room**: Foyer. **Length**: 8 m.

**Monitoring**

Installation of an outdoor sensor (T and RH) to assess fresh air intake for induced natural ventilation formulas.

**Intervention abroad**

The outdoor space of the building has several areas for both sports practice and recreational time. It has a paved area located on the west façade, in the area closest to the main entrance to the school. In addition, the area on the south façade of the building is also paved, although it is in worse condition.

A paved sports field is located in front of the south façade.

The entire area around the perimeter of the building and in the southern part of the plot there is a channel for collecting rainwater from both the building and the pavement. Although there is a significant proportion of unpaved ground, the soil does not have adequate drainage capacity.

*INITIAL SITUATION INDICATORS*

**Climate change adaptation and mitigation.**

I1.1 Indoor temperature of the building.

The following table shows the status of the sensors installed at CEIP Gabriela Mistral, the classroom, the façade on which the classroom is located and the number of students in the classroom during the 2020/2021 academic year. Sensors 350, 505, 513, 513, 522 and 568 were installed in June 2019. In the initial period of operation there were some connection problems and some data sets were lost. On installation from CARTIF it was believed that the sensors were recording but when they have been connected to the wifi the data has been lost and the causes are not known. The records have started to be correct since January 28, 2020002E.

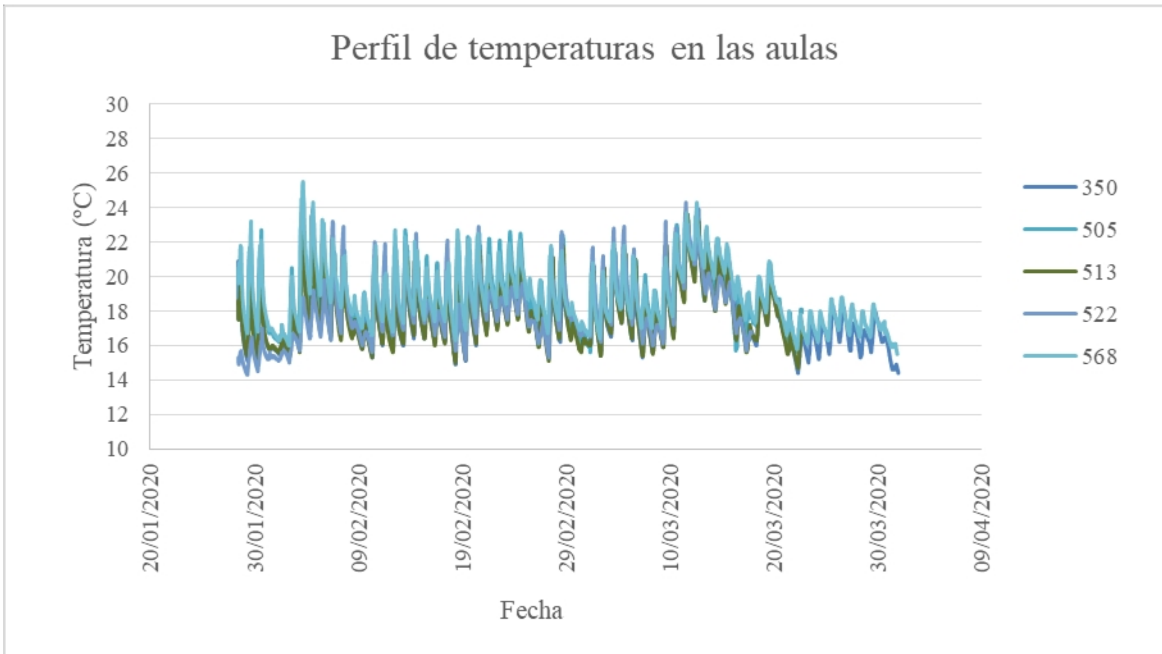



*Figure 3 Temperature profile in the classrooms of Escola EB1 Horta das Figueiras.*

*Table 2. Location of sensors and occupancy of classrooms at Escola EB1 Horta das Figueiras.*

| **Sensor** | **350** | **505** | **513** | **522** | **568** |
|---|---|---|---|---|---|
| **Plant** | Floor 1 | Floor -1 | Ground Floor | Ground Floor | Multipurpose space |
| **Facade** | South | South | South | South | East/West |
| Students | 25 | 25 | 25 | 25 | 100. Use occasional |

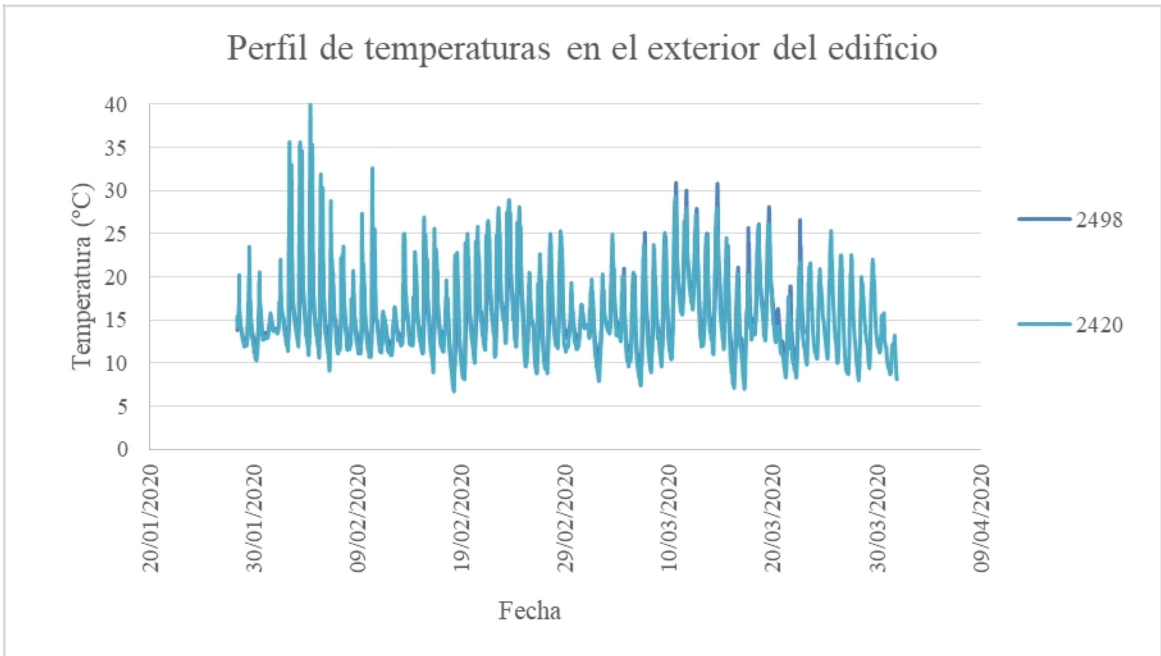
As can be seen in the previous figure, the temperature profiles in the classrooms are similar with variations in magnitude depending on the facade on which they are located or the occupancy they have.

I1.2 Building envelope temperature

During the summer of 2020, prior to the interventions, a complete report will be carried out in the main areas of the interventions with thermal camera.

I1.3 External environmental conditions of the building

Two sensors have been placed outside the building, one on the west façade (2498) and the other on the east façade (2420). The figure below shows the evolution of the outdoor temperatures. These sensors were installed in September 2019. Some values are not currently collected because the sensor has lost the *wifi* network signal. The equipment continues to record and will send the values when reconnected.




*Temperature profile on the outside of the building. Sensor 2498 east face and sensor 2420 west face.*

As can be seen in the previous figure, the temperature profiles on both facades follow similar profiles, but there is a greater variation on the west side and somewhat higher maximum temperatures for the dates of the interval.

I1.4 Modeling of the energy savings produced

The initial value for this indicator is 0. The starting point is a situation in which no cooling is carried out when there are no thermal comfort conditions in the classrooms.

I1.5 Estimated heating savings In-process data

request and recording.

**Water management.**

I2.1 Savings in water consumption in irrigation water for green areas in the pilot buildings.

Data request and recording in process.

I2.2 Savings in rainwater management.

*Table 3 shows* the areas related to the school. Currently, the areas considered as "green" would infiltrate water into the ground and the rest are collected and conveyed to public sewers. The truth is that the soil, due to lack of proper maintenance, is quite sealed and possibly some of the water from these areas may occasionally pass into public sewers, but this will not be considered in these calculations.

**Management of green areas.**

I3.1Increased plant and animal biodiversity. Data request

and registration in process.

I3.2 Number of native plant species Data request

and registration in process.

**Air quality**

I4.1 Carbon dioxide concentration inside the classroom.

Sensors are currently recording the concentrations at the school. Due to an initial problem, the information from the first records was lost. The records of the initial situation continue to be recorded.

I4.2 Noise reduction levels from the outside.

During the summer of 2020, prior to the interventions, a survey will be carried out in the main areas of the interventions with sound level meter and standard noise.

I4.3 Number of bioindicator species installed and area covered with these bioindicators.

Registration information in process.

I4.4 Training in the observation of bioindicator species of contamination. Recording of

information in process.

**Urban regeneration**

I5.1 Energy efficiency measures.

Collection of information in process.

I5.2 Increase in green area.

The following table shows the surface areas related to the project. The school currently has a total area of green areas of 1,316.2 $m^2$ .

*Table 3. Representative surfaces of the school.*

| | Sup. Built per floor ($m^2$) | | Sup. Total Built ($m^2$) | Free Space ($m^2$) | Green areas ($m^2$) | % Green areas | Total plot area ($m^2$) |
|---|---|---|---|---|---|---|---|
| **ÉVORA** | PB | 392,55 | 585,2 | 3998,85 | 1316,2 | 32,91 | 4391, 40 |
| | P1 | 192,65 | | | | | |

**Governance and participation**

I6.1 Citizen perception of urban nature.

The indicators for this challenge (I6.2, I6.3 and I6.4) relating to new learning policies, strategic plans, open participatory processes and other actions carried out with user participation are initially considered 0 and actions of this type promoted by the project or arising in the context of the project will be counted.

**Social cohesion**

The indicator corresponding to this challenge, I7.1 No. of agreements and disagreements will initially be considered as 0 and agreements or disagreements within the scope of the project promoted by the actions of the project will be counted.

**Public health and welfare**

I8.1 Reduction in the number of absences and absenteeism of students

and teachers. Data collection still in progress.

Indicator I.8.2. Use of the NBS by users will be analyzed after implementation by means of specific questionnaires for each school and the results will then be evaluated.

**Economic opportunities and employment**

Indicators I9.1 Number of jobs created and I9.2 Creation of new capacities in self-employed and businesses in the area related to the NBS will be analyzed after the implementations through specific questionnaires for each school and then the results will be evaluated.

I9.3 Reduction of absenteeism among school staff. Application and

recording of data in process.

## 6.2 Porto

*INTRODUCTION*

Following the general objective of the project "to contribute to increase resilience in buildings through the implementation of Nature-Based Solutions as prototypes of climate adaptation and improvement of *well-being* in buildings", a series of actions are proposed in this building to improve the thermal comfort of the children and teachers of the center, increase the amount of green surfaces in the school space in a sustainable way, reduce the carbon footprint of the buildings, improve water management in the buildings, recover and promote local biodiversity in the urban environment and raise awareness of the value of nature and the ecosystem services[1] that are produced.

In general, it is proposed to reduce the impact of solar radiation on the building envelope and prevent the entry of direct solar radiation through the openings, generate air circulation inside the building in summer with naturally "cooled" air, increase seasonal shaded areas on the outside of the buildings and install draining floors and other solutions to capture all rainwater and not divert it to the public sewage system.

In addition, the air renewal achieved with these actions should reduce the levels of carbon dioxide inside the classrooms. This is an impact associated with the actions that will improve the health and well-being of students and teachers.

Finally, we consider that the involvement of students, faculty and the AMPA is crucial for this project to be integrated into the academic curriculum of the school, and to avoid vegetation losses, transmitting to the students the benefits they will bring when the plantations are fully developed (5 years maximum). If the school already worked on a project basis, this action would make it possible to propose new projects aimed at studying many aspects of experimental subjects (pollinators in the area and their importance in plant production; increasing urban diversity associated with sustainable plans; experimentation in growing plants with potential for extensive cover in extreme climate zones; variations in temperature and other parameters for use in mathematics, for example; etc.).

[1] Ecosystem services refers to services provided by ecosystems such as temperature regulation, water management, biodiversity enhancement, pollutant reduction, etc.

*LOCATION*

Escola EB1 Mello Falcão

R. do Falcão 708, Porto, Portugal



*Figure 5. Location of Escola EB1 Mello Falcão (Porto, Portugal).*

*CLIMATIC DATA*

Porto's climate is humid and temperate. Summers are generally sunny and hot with average temperatures ranging from 15°C minimum to 24°C maximum. Winter temperatures are mild and average 6°C minimum and 16°C maximum.

In a year, the average rainfall is 1,178 mm. The driest month is July, with 15 mm of rainfall. The highest amount of precipitation occurs between the months of November and January with more than 150 mm monthly average.

The warm season lasts 3.1 months, from June 19 to September 24. The hottest day of the year is July 29, with an average maximum temperature of 24 °C and an average minimum temperature of 15 °C.

The cool season lasts 3.5 months, from November 22 to March 6. The coldest day of the year is January 24, with an average minimum temperature of 6°C and an average maximum of 14°C.
°C. Complete climatic data for this location are presented in Annex I.

*BUILDING DESCRIPTION*

The building has several different roof areas. First, the classrooms are covered by fiber cement slabs, roofs 1 (4 units) and 2 (3 units) with a slope. On the other hand, roofs 3 and 4 are flat, horizontal and, in principle, walkable (although they do not have perimeter protections).

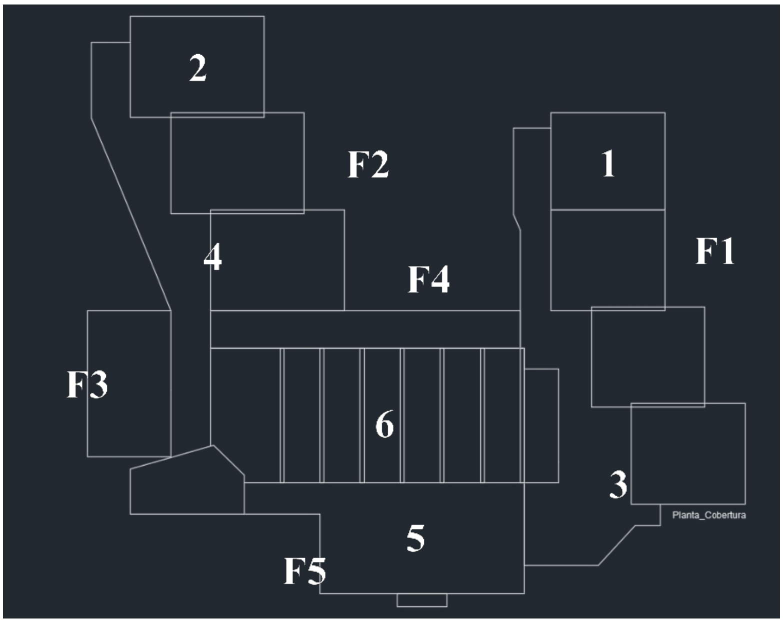



*Figure 6. Schematic diagram of roof and plant situation*

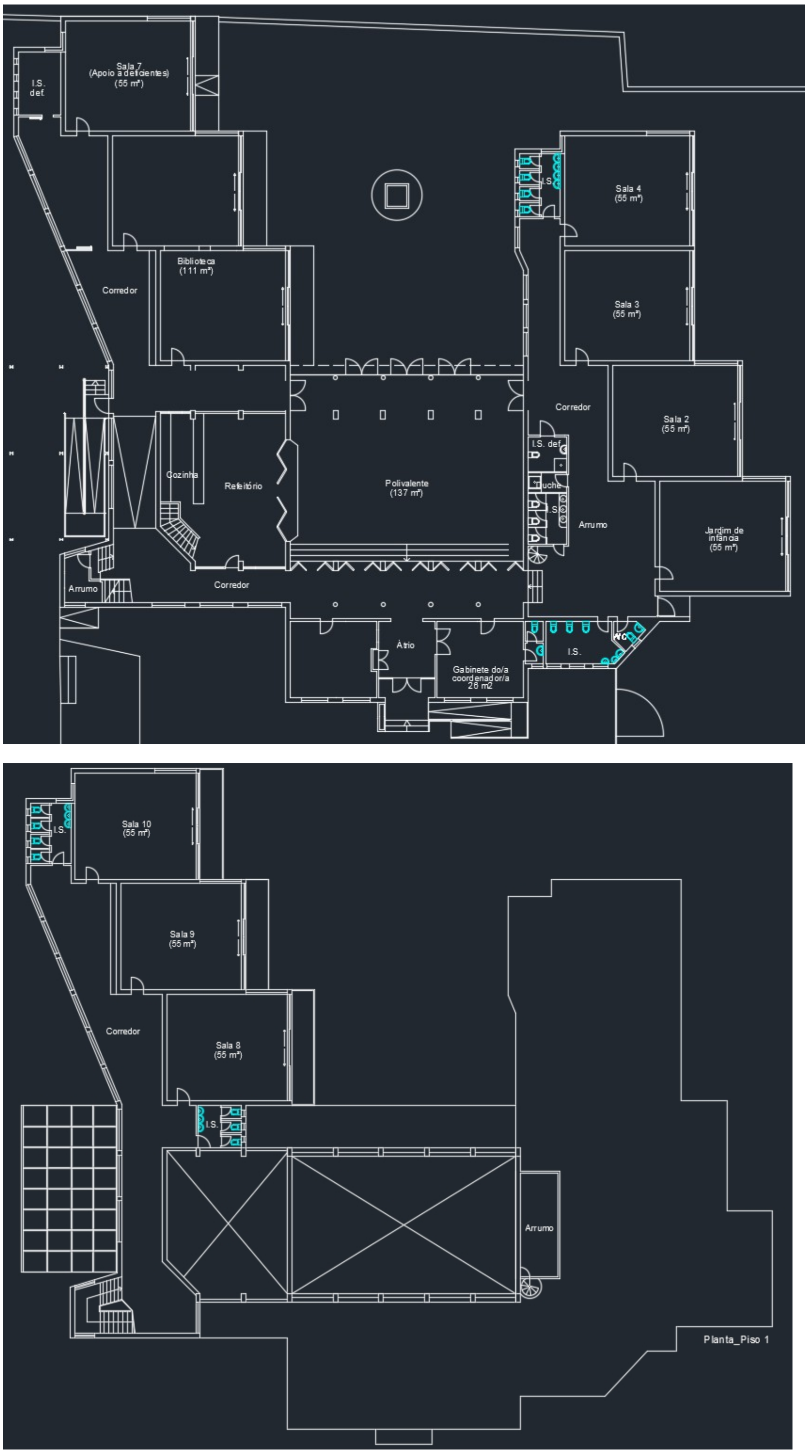



*Figure 7. Floor plans of classrooms and spaces.*

On the other hand, decks 5 and 6 are also flat horizontal decks at two different heights and with sections separated by linear protrusions.

Decks 1 and 2.

Decks 3 and 4.

Decks 5 and 6.

*Figure 8. Example images of the types of roofs on the building.*

In relation to the facades, two typologies can be distinguished. The north, east and west facades generally have small openings and the south facade has large openings.

North façade

West façade

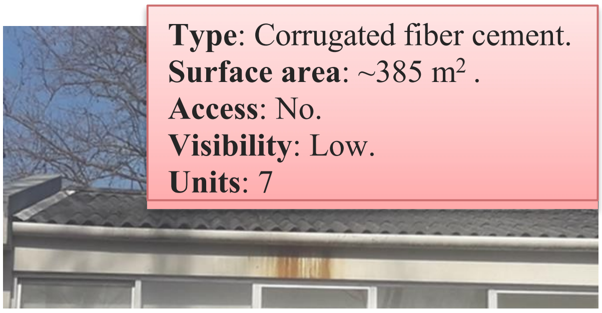
South façade

East façade

*Figure 9. Images of the building facades.*

**Decks 1 and 2.**

These decks primarily cover classrooms. Deck 1 covers classrooms 2-4 and the kindergarten and deck 2 covers classrooms 8-10. They are non-accessible, low-impact roofs (visible only from nearby tall buildings). They are all pitched roofs finished with corrugated fiber cement boards.



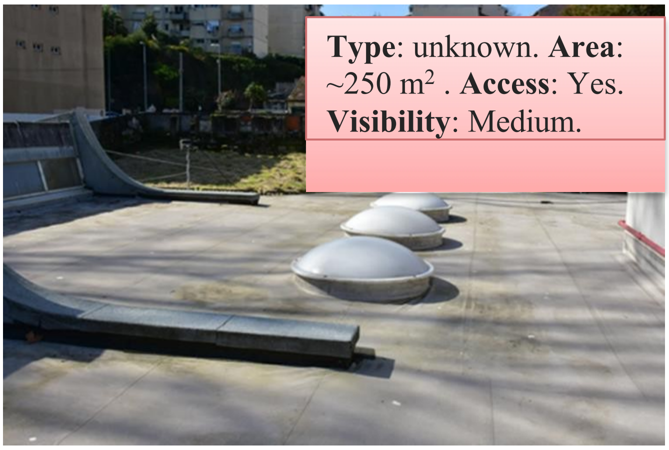
**Type**: Corrugated fiber cement.
**Surface area**: ~385 $m^2$ .
**Access**: No.
**Visibility**: Low.
**Units**: 7

**Monitoring**

Four sensors ($CO_2$, T and RH) have been installed in classrooms 2, 3, 4, 9 and 10.

**Decks 3 and 4.**

Decks 3 and 4 cover common areas, mainly corridors and bathrooms. They have access but are not usually used because they do not have perimeter protection.



**Type**: unknown. **Area**: ~250 $m^2$ . **Access**: Yes. **Visibility**: Medium.

**Monitoring**

No special dedicated monitoring.

**Decks 5 and 6.**

Both cover common areas and a large multipurpose space.

**Type**: Panel. **Area**: 145 $m^2$ . **Access**: No. **Visibility**: Low.

**Monitoring**

1 sensor ($CO_2$, T and RH) has been installed in the multipurpose area.

### South façade F1


The south façade is the one that receives the most sunlight in the school and is where the main windows of the classrooms are located.

### Monitoring

Sensors ($CO_2$, T and RH) have been installed in classrooms 2, 4. In addition, an exterior south façade sensor (T and RH) has been installed to implement the induced natural ventilation formulas.

### South façade F2


The south façade is the one that receives the most sunlight in the school and is where the main windows of the classrooms in this area are located.

### Monitoring

Installation of a sensor ($CO_2$, T and RH) in classrooms 9 and

### East façade


The east façade is the one that receives the most sunlight in the morning hours. Only the glazed east façade corresponding to the multipurpose space is analyzed. No information is available for the rest of the east facades.

### Monitoring

1 sensor ($CO_2$, T and RH) has been installed in the multipurpose area.

**West façade**

The west façade is the one with the main entrance to the school.

**Monitoring**

No special dedicated monitoring.

**North façade**

This façade has an auxiliary entrance to the school covered with a structure of translucent material.

**Monitoring**

An exterior north façade (under the existing roof) sensor (T and RH) has been installed to implement the natural induced ventilation formulas.

**Outdoor area.**

In the outdoor area there are two main areas of use of the school. In front of the west and north facades, which are the main entrance areas to the school. Both areas are sealed paved with low drainage capacity and water collection pits. There is a green area at the entrance stairs to the school on the west side. On the other hand, in front of the two southern facades of the school there are two exterior areas paved in a sealed manner with water collection boxes. These areas have some trees that provide some shade to the playground. These areas are used as playgrounds.

*Figure 10. Exterior area in front of south façade F2.*

<u>*INITIAL SITUATION INDICATORS*</u>

**Climate change adaptation and mitigation.**

I1.1 Indoor temperature of the building.

The table below shows the location of the sensors installed at Escola EB1 Mello Falcão, the classroom, the facade on which the classroom is located and the number of students in the classroom during the 2020/2021 academic year. The sensors were installed on October 1, 2019. At the time of installation the school wifi network was used but due to problems with security protocols the sensors have not been able to send. The installation of a new wifi network dedicated only to the sensors has been arranged but has not yet been implemented. However, the sensors continue to register.

*Table 4. Location of sensors and occupancy of classrooms at CEIP Gabriela Mistral.*

| Sensor | 995 | 527 | 1827 | 2425 | 2426 | 1801 |
|---|---|---|---|---|---|---|
| **Plant** | Room 10 Floor 2 | Room 8 Floor 2 | Room 4 Floor 0 | Kinder garten Floor 0 | Multipur pose room | Aisle |
| **Facade** | South | South | South | South | This | Interior |
| **Students** | | | | | - | - |

I1.2 Building envelope temperature

During the summer of 2020, prior to the interventions, a complete report will be carried out in the main areas of the interventions with thermal camera.

I1.3 External environmental conditions of the building

Two sensors have been located on the exterior of the building, one on the north façade (2470) and one on the south façade (2494). The sensors were installed on 01/10/2019 and have been recording since then. They have not been able to connect to the *wifi* network yet but when connected they will send the recorded information.

I1.4 Modeling of the energy savings produced

The initial value for this indicator is 0. The starting point is a situation in which no cooling is carried out when there are no thermal comfort conditions in the classrooms.

I1.5 Estimated heating savings In-process data

request and recording.

**Water management.**

I2.1 Savings in water consumption in irrigation water for green areas in the pilot buildings.

Data request and recording in process.

I2.2 Savings in rainwater management. Data

request and recording in process.

**Management of green areas.**

I3.1Increased plant and animal biodiversity. Data request

and registration in process.

I3.2 Number of native plant species Data request

and registration in process.

**Air quality**

I4.1 Carbon dioxide concentration inside the classroom.

Sensors are currently recording the concentrations at the school. Data has not been collected due to a problem with the wifi connection that will be fixed.

I4.2 Noise reduction levels from the outside.

During the summer of 2020, prior to the interventions, a survey will be carried out in the main areas of the interventions with sound level meter and standard noise.

I4.3 Number of bioindicator species installed and area covered with these bioindicators.

Request and registration of data in process.

I4.4 Training in the observation of bioindicator species of contamination.

Application and recording of data in process.

**Urban regeneration**

I5.1 Energy efficiency measures.

Collection of information in process.

I5.2 Increase in green area

The following table shows the surface areas related to the project. The school currently has a total area of green areas of 409.74 m² but a very small part of it corresponds to the playground.

*Table 5. Representative surfaces of the school.*

| | | Sup. Built per floor (m²) | Sup. Total Built (m²) | Free Space (m²) | Green areas (m²) | % Green areas | Total plot area (m²) |
|---|---|---|---|---|---|---|---|
| **OPORTO** | P-1 | 80,69 | 1.625,37 | 2.393,60 | 409, 74 | 17,12 | 3.582,47 |
| | PB | 1.188,87 | | | | | |
| | P1 | 355,81 | | | | | |

**Governance and participation**

I6.1 Citizen perception of urban nature.

The indicators of this challenge (I6.2, I6.3 and I6.4) related to new learning policies, strategic plans, open participatory processes and other actions carried out with user participation are initially considered 0 and actions of this type promoted by the project or arising in its context will be counted.

**Social cohesion**

The indicator corresponding to this challenge, I7.1 No. of agreements and disagreements will initially be considered as 0 and agreements or disagreements within the scope of the project promoted by the actions of the project will be counted.

**Public health and welfare**

I8.1 Reduction in the number of absences and absences of students and

teachers. Data collection still in progress.

Indicator I.8.2. Use of the NBS by users will be analyzed after implementation by means of specific questionnaires for each school and the results will then be evaluated.

**Economic opportunities and employment**

Indicators I9.1 Number of jobs created and I9.2 Creation of new capacities in self-employed and businesses in the area related to the NBS will be analyzed after the implementations through specific questionnaires for each school and then the results will be evaluated.

I9.3 Reduction of absenteeism among school staff. Application and

recording of data in process.

## 6.3 Solana de los Barros

*INTRODUCTION*

Following the general objective of the project "to contribute to increase resilience in buildings through the implementation of Nature-Based Solutions as prototypes of climate adaptation and improvement of comfort in buildings", this building seeks to improve the thermal comfort of children and teachers of the center, increase the amount of green areas in the school space in a sustainable way, reduce the carbon footprint of buildings, improve water management in them, recover and promote local biodiversity in the urban environment and raise awareness of the value of nature and ecosystem services that occur.

In general, it is proposed to reduce the impact of solar radiation on the building envelope and prevent the entry of direct solar radiation through the openings, generate air circulation inside the building in summer with naturally "cooled" air, increase seasonal shaded areas on the outside of the buildings and install draining floors and other solutions to capture all rainwater and not divert it to the public sewage system.

In addition, the air renewal achieved by these actions should reduce carbon dioxide levels inside the classrooms. This is an impact associated with the actions that will improve the health and well-being of students and teachers.

Finally, the involvement of students, the teaching staff and the AMPA is considered crucial for this project to be integrated into the school's academic curriculum, so that there is no loss of plants or of the benefit they would provide when the plantations are fully developed (5 years maximum). If the school already worked on a project basis, this action would allow new projects to be proposed with the objective of studying many aspects of the experimental subjects (pollinators in the area and their importance in plant production; increasing urban diversity associated with sustainable plans; experimentation in the cultivation of plants with potential for extensive cover in extreme climate zones; variations in temperature and other parameters for use in mathematics, for example; etc.).

First the climatic conditions of the area will be reviewed, then the characteristics of the building and finally a review of the status of the proposed impact assessment indicators will be carried out.

*LOCATION*

C.E.I.P. Gabriela Mistral

Plaza Colegio Nuevo

06209 Solana de los Barros (Badajoz)

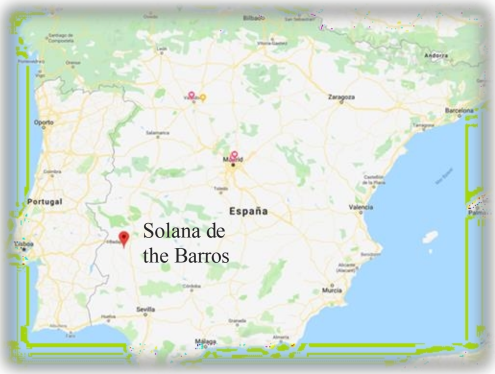





*Figure 11. Location of CEIP Gabriela Mistral. Solana de los Barros (Badajoz, Spain).*

*CLIMATIC DATA*

In Badajoz, summers are very hot, dry and mostly clear and winters are cold and partly cloudy. During the course of the year, the temperature generally varies from 3 °C to 35 °C and rarely drops below -2 °C or rises above 39 °C. (https://es.weatherspark.com).

Precipitation is 507 mm per year. The driest month is July, with 3 mm of rain. The highest amount of precipitation occurs in November, with an average of 69 mm.

The hot season lasts 3.0 months, from June 14 to September 13, and the average daily maximum temperature is over 30 °C. The hottest day of the year is July 29, with an average maximum temperature of 35 °C and an average minimum temperature of 18 °C.

The cool season lasts 3.6 months, from November 16 to March 4, and the average daily maximum temperature is less than 18 °C. The coldest day of the year is January 18, with an average minimum temperature of 3 °C and an average maximum of 14 °C.

Complete climatic data for this location are presented in Annex I.

*BUILDING DESCRIPTION*

The school is located to the east of the town of Solana de los Barros. The plot has a land area of 5,511 $m^2$ . On it there are 2 buildings: the main building for teaching, and a building for dining room. The first, with an "L" shape, is formed by an original building built in 1979, and an annex built in 2007, currently forming a single building. It is in the area of the latter where the present project will be carried out. There are 4 gravel roofs, at least two of which are passable.

The original building is to be renovated for the replacement of exterior carpentry, and although it would be susceptible to the action that concerns us, as there are simultaneous actions to be carried out in the same building.
-This would not make it possible to know to what extent the European project solutions have an impact on improving comfort - should be ruled out as an area of action.

The annex building, which has facades to the EAST and SOUTH EAST, very sunny most of the school hours, and which has several accessible roofs, where to interact with the solutions to be implemented, has been chosen to act.

The area of the building on which we are acting, which we will call "annex", has a rectangular shape of about 38 x 15 meters. The longitudinal facades are oriented to the east and west.

The annex has three levels in height which, using the nomenclature of the original project consulted, are as follows:

-Level -1, located below the access level of the main building. On this level are located 4 classrooms of early childhood education, circulations, staircase and elevator, and the exits to the outdoor playground located at this level, on the east side. There is also a porch and auxiliary facilities (warehouse, boiler room, fuel tank, and unused premises).

-Level 1: It coincides with the access level of the main building, and where it communicates. It has a communication corridor with the original building, 4 primary education classrooms, toilets, circulations, staircase and elevator, as well as access to the outdoor patio in the west area.

-Level 2: It contains 2 classrooms and library, circulation, stairs and elevator.

The annex has several non-trafficable flat roofs, but with access or the possibility of access from different levels, which has motivated, among other aspects, the choice of the building for this pilot project, since the roofs where nature-based solutions are implemented will be visible and visitable by students, which makes it possible to achieve added benefits related to school awareness.

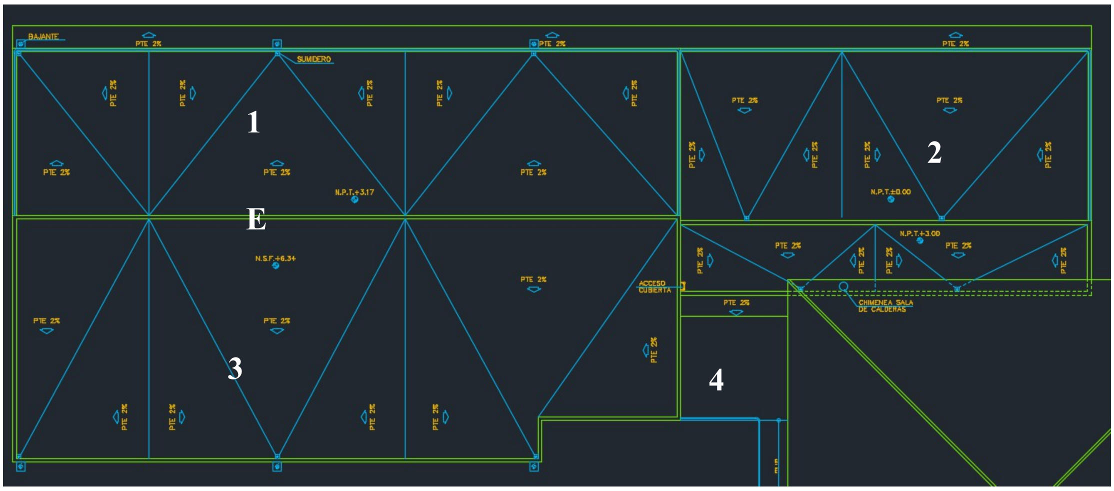



*Figure 12. Diagram of the four roofs of the building ANNEX.*

On the east side of the building there are several differentiated facade sections on which to act.

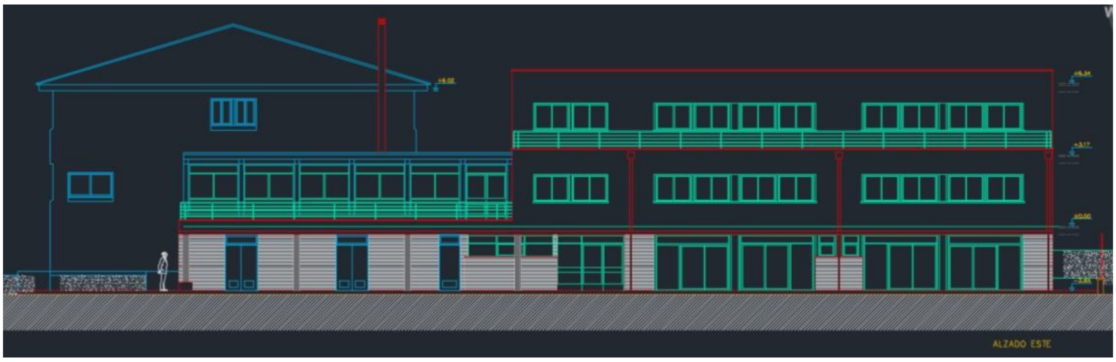
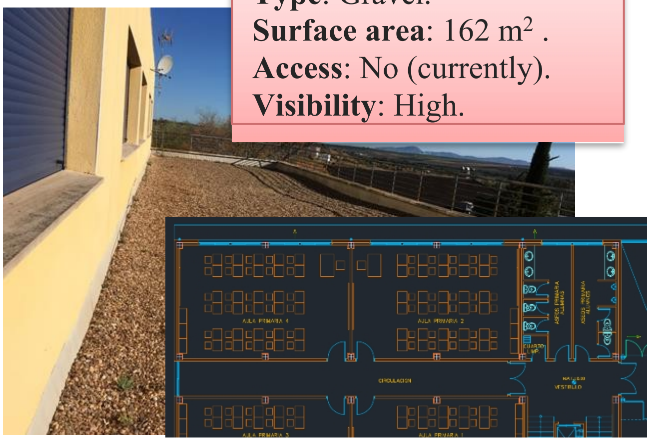



*Figure 13. East façade of the building.*

**Type**: Gravel.
**Surface area**: 162 m$^2$ .
**Access**: No (currently).
**Visibility**: High.



**Deck 1 / Facade E1.**

Deck 1 covers elementary classrooms 2 and 4, so it would have a direct impact on these classrooms, which are located on level 1. No access at present, but there are plans to build one. High visual impact from classrooms. Facade E1 is the side of the multipurpose room (connects east/north/west facade) and an access corridor.

**Monitoring**

Sensors ($CO_2$, T and RH) have been installed in primary 2 and 4 classrooms.

**Deck 2 / glass corridor**

Deck 2 has access from a glazed gallery as can be seen in the image. This deck is over a multipurpose office, a lobby, the boiler room and a storage room, as well as an open space. It currently has access. High visual impact from inside the school.

**Type**: Gravel.
**Surface**: 89 m$^2$ .
**Access**: Yes.
**Visibility**: High.

**Deck 3**

On the other hand, Deck 3 covers the multi-purpose and split classrooms for primary 1 and 2.

Occasionally. There is currently no access or perimeter protection. No visual impact from inside the school and very low from the outside.

**Type**: Gravel. **Surface**: 203 m$^2$ . **Access**: No. **Visibility**: Low.


**Deck 4**

Deck 4 covers only the glazed gallery.

**Type**: Gravel. **Surface**: 60 m$^2$ . **Access**: No. **Visibility**: Medium.

**Monitoring**

Proposed to use it as a temperature reference with thermal imaging once the vegetation is in place on the rest of the canopies. The challenge will be to find a way to image all canopies.

**East façade E2**

This façade covers the ground and first floors, which contain the infant (ground) and primary (1st floor) classrooms. It receives high insolation during the morning.

**Monitoring**

Two sensors ($CO_2$, T and RH) have been installed in primary 2 and 4 classrooms and a T and RH sensor on the outside of the façade.

**West façade**

This façade covers the three floors of the annex building and also has an auxiliary entrance to the building.

**Monitoring**

A T and RH sensor has been installed outside.

**South façade**

The south façade is the main façade of the old building and the main entrance to the school. It receives a great deal of sunlight because it has no shading elements. As mentioned above, all the windows on this façade are scheduled to be renovated due to their poor condition. This may interfere with monitoring.

**Monitoring**

A sensor ($CO_2$, T and RH) has been installed in the 5th classroom. It can be considered to leave a classroom uncovered and monitor as a reference, assessing the aesthetics. In addition, conventional awnings can be installed in another classroom to evaluate this solution.

**North façade**

The north façade is partially covered by trees and an irrigated garden area.

**Outdoor area.**

In the outdoor area there are three main areas for school use. In front of the east façade is the children's playground area with sandy soil and sparse vegetation. In front of the south façade is the main entrance to the school and an area paved with concrete. It is used as a playground for some activities and as a waiting area for parents at the school exit. Finally, in front of the east façade there is an area for sports practice used, together with the area in front of the north façade as a playground and primary school playground.

*INITIAL SITUATION INDICATORS*

**Climate change adaptation and mitigation.**

I1.1 Indoor temperature of the building.

The following table shows the location of the sensors installed at CEIP Gabriela Mistral, the classroom, the façade on which the classroom is located and the number of students in the classroom during the 2020/2021 academic year. Sensors 502, 554, 557 and 997 were installed in May 2019. In the initial period of operation there were some connection problems and they were lost.

some data sets. Sensors 1803 and 2422 were installed in September 2019. Since then all sensors have been sending correctly recorded information.

*Table 6. Location of sensors and occupancy of classrooms at CEIP Gabriela Mistral.*

| **Sensor** | **502** | **554** | **557** | **977** | **1803** | **2422** |
|---|---|---|---|---|---|---|
| **Plant** | Floor 1 Old Buildin g | Floor -1 Childre n's | Ground Floor | Groun d Floor | Floor -1 Childre n's | Ground Floor |
| **Facade** | South | This | This | This | West | West |
| Students | 12 | 14 | 19 | Normally empty. | 15 | 18 |

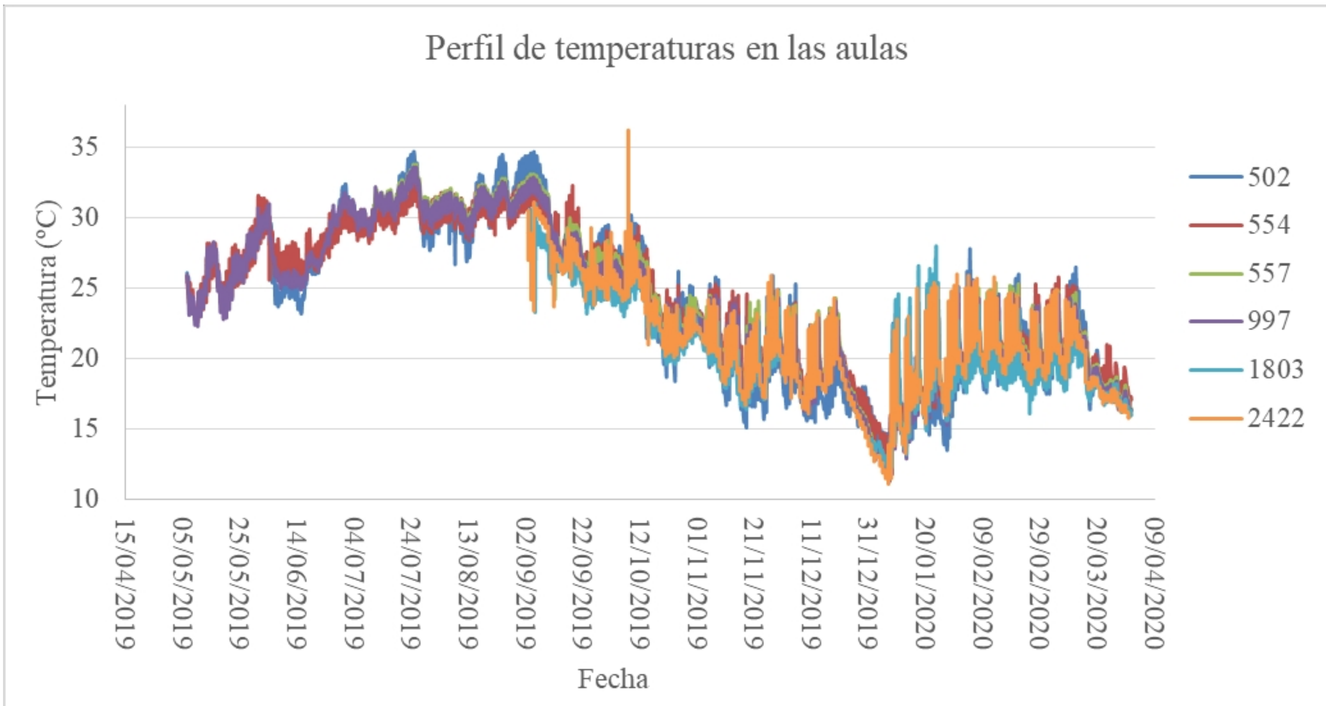



*Figure 14. Temperature profile in the classrooms of CEIP Gabriela Mistral between May19 and Mar20.*

As can be seen in the previous figure, the temperature profiles in the classrooms are similar with variations in magnitude depending on the facade on which they are located or the occupancy they have.

The following table shows the summary of the average, maximum and minimum monthly values for each of the classrooms.

*Table 7. Mean, maximum and minimum monthly values of the sensors installed at CEIP Gabriela Mistral.*

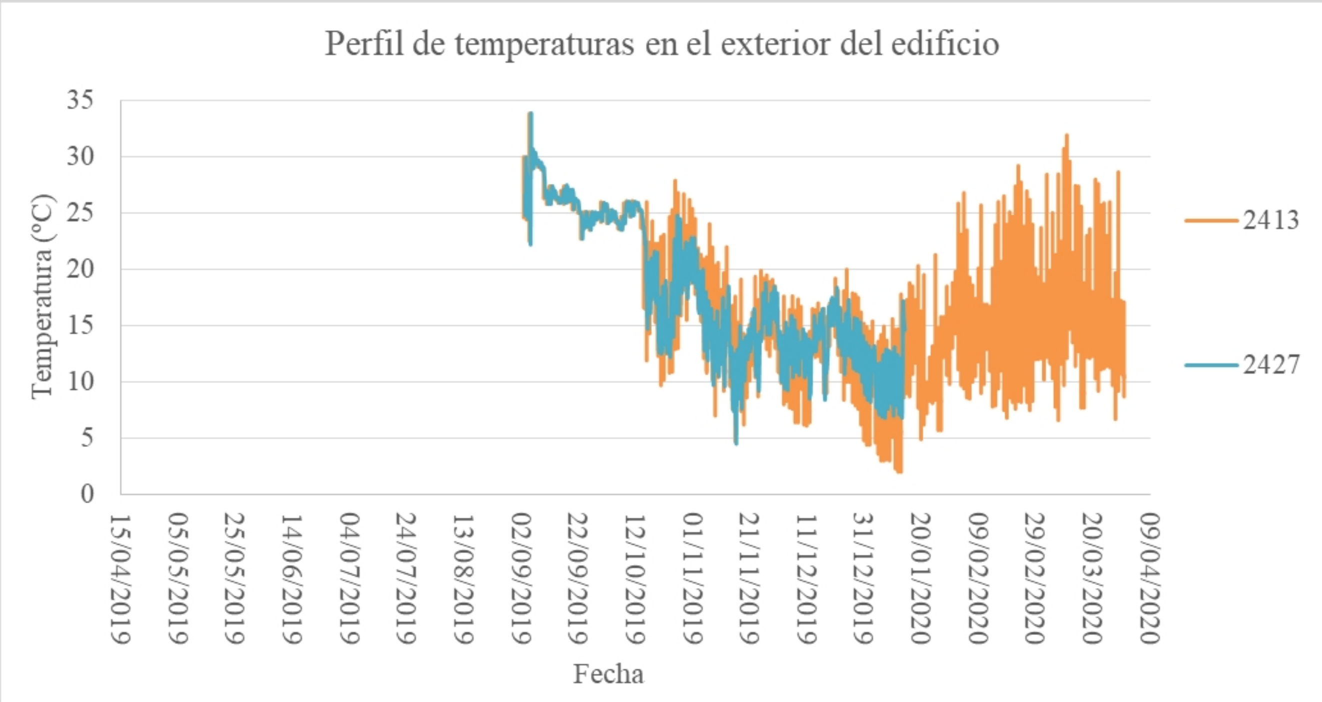
| **Temperatures (ºC)** | **2019** | | | | | | | | **Total** | **2020** | | | **Total** | **T** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **2019** | **1** | **2** | **3** | **2020** | |
| **502 - South** | | | | | | | | | | | | | | |
| **Average** | 25,5 | 26,8 | 30,9 | 30,9 | 29,3 | 24,7 | 19,9 | 17,9 | **25,5** | 16,6 | 21,0 | 20,7 | **19,2** | **23,8** |
| **Maximum** | 26,1 | 32,4 | **34,7** | 34,5 | 34,7 | 30,2 | 25,9 | 25,3 | **34,7** | 25,1 | **27,8** | 26,5 | **27,8** | **34,7** |
| **Minimal** | 24,9 | 23,2 | 27,7 | 26,7 | 23,6 | 18,4 | 15,1 | **14,7** | **14,7** | **12,6** | 17,6 | 16,4 | **12,6** | **12,6** |
| **554 - East** | | | | | | | | | | | | | | |
| **Average** | 25,9 | 28,0 | 30,5 | 30,8 | 28,9 | 24,7 | 21,2 | 18,9 | **26,1** | 16,9 | 21,0 | 20,2 | **19,3** | **24,2** |
| **Maximum** | 31,6 | 31,4 | **33,2** | 32,6 | 33,0 | 29,4 | 25,3 | 24,0 | **33,2** | 23,3 | 25,3 | **25,8** | **25,8** | **33,2** |
| **Minimal** | 22,6 | 25,3 | 28,2 | 28,4 | 25,6 | 20,9 | 17,9 | **15,1** | **15,1** | **12,9** | 18,4 | 16,5 | **12,9** | **12,9** |
| **557 - East** | | | | | | | | | | | | | | |
| **Average** | | | 31,7 | 31,3 | 29,1 | 24,6 | 21,1 | 18,9 | **25,8** | 16,8 | 21,5 | 20,0 | **19,4** | **23,6** |
| **Maximum** | | | **33,8** | 32,8 | 33,1 | 28,4 | 24,8 | 24,3 | **33,8** | 24,2 | **25,4** | 24,9 | **25,4** | **33,8** |
| **Minimal** | | | 29,8 | 29,1 | 24,2 | 20,4 | 17,4 | **14,2** | **14,2** | **11,6** | 18,7 | 16,1 | **11,6** | **11,6** |
| **997 - East** | | | | | | | | | | | | | | |
| **Average** | 26,0 | 27,6 | 31,1 | 31,0 | 28,8 | 24,0 | 20,9 | 18,6 | **26,0** | 16,4 | 21,1 | 19,7 | **19,1** | **24,1** |
| **Maximum** | 30,7 | 31,8 | **33,6** | 32,6 | 32,9 | 27,4 | 24,5 | 24,1 | **33,6** | 24,6 | **25,5** | 24,8 | **25,5** | **33,6** |
| **Minimal** | 22,3 | 24,9 | 28,7 | 28,6 | 25,4 | 20,1 | 17,3 | **13,9** | **13,9** | **11,3** | 18,5 | 16,0 | **11,3** | **11,3** |
| **1803 - West** | | | | | | | | | | | | | | |
| **Average** | | | | | 26,4 | 22,9 | 19,8 | 18,9 | **22,9** | 17,1 | 19,6 | 18,6 | **18,4** | **20,6** |
| **Maximum** | | | | | **31,0** | 26,0 | 23,6 | 19,6 | **31,0** | **28,0** | 23,8 | 23,5 | **28,0** | **31,0** |
| **Minimal** | | | | | 23,2 | 19,6 | **16,4** | 18,3 | **16,4** | **11,7** | 16,1 | 15,9 | **11,7** | **11,7** |
| **2422 - West** | | | | | | | | | | | | | | |
| **Average** | | | | | 27,2 | 23,7 | 20,4 | 18,4 | **22,3** | 17,2 | 21,1 | 19,3 | **19,1** | **20,9** |
| **Maximum** | | | | | 31,1 | **36,2** | 25,9 | 24,3 | **36,2** | **26,0** | 25,9 | 24,9 | **26,0** | **36,2** |
| **Minimal** | | | | | 23,4 | 20,1 | 16,7 | **13,8** | **13,8** | **11,1** | 18,2 | 15,8 | **11,1** | **11,1** |

I1.2 Building envelope temperature

During the summer of 2020, prior to the interventions, a complete report will be carried out in the main areas of the interventions with thermal camera.

I1.3 External environmental conditions of the building

Two sensors have been placed outside the building, one on the west façade (2427) and the other on the east façade (2413). The figure below shows the evolution of the outdoor temperatures. These sensors were installed in September 2019. Some values are not currently collected because the sensor has lost the *wifi* network signal. The equipment continues to record and will send the values when reconnected.




*Temperature profile on the outside of the building. Sensor 2413 east face and sensor 2427 west face.*

As can be seen in the previous figure, the temperature profiles on both facades follow similar profiles, but there is a greater variation on the east side.

The following table shows a summary of the average, maximum and minimum monthly values for each of the two facades. The maximum and minimum values have been highlighted for each of them in the two years currently covered by the monitoring.

*Table 8. Monthly mean, maximum and minimum values of outdoor sensors at CEIP Gabriela Mistral.*

| Temperatures (ºC) | 2019 | | | | | | | | Total | 2020 | | | Total | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2427 - west** | | | | | | | | | | | | | | |
| **Average** | - | - | - | - | 26,5 | 21,3 | 14,3 | 13,4 | **18,7** | 10,3 | - | - | **10,3** | 17,9 |
| **Maximum** | - | - | - | - | 33,9 | 26,0 | 22,8 | 18,4 | **33,9** | 17,2 | - | - | **17,2** | 33,9 |
| **Minimal** | - | - | - | - | 22,2 | 12,2 | 4,5 | 8,4 | **4,5** | 6,8 | - | - | **6,8** | 4,5 |
| **2413 - east** | | | | | | | | | | | | | | |
| **Average** | - | - | - | - | 26,5 | 21,6 | 14,7 | 12,6 | **18,7** | 10,6 | 15,3 | 16,3 | **14,0** | 16,7 |
| **Maximum** | - | - | - | - | 33,8 | 27,9 | 25,4 | 20,0 | **33,8** | 21,3 | 29,2 | 31,9 | **31,9** | 33,8 |
| **Minimal** | - | - | - | - | 22,5 | 9,7 | 4,7 | 4,8 | **4,7** | 2,0 | 6,8 | 6,6 | **2,0** | 2,0 |

### I1.4 Modeling of the energy savings produced

The initial value for this indicator is 0. The starting point is a situation in which no cooling is carried out when there are no thermal comfort conditions in the classrooms.

### I1.5 Estimated heating savings

Currently, data on heating oil and electric energy consumption has been collected for the year 2019 and so far in 2020. In the following months we will try to collect data on the consumption of previous years and the remaining months until the interventions are carried out. The following tables show the consumption of heating oil and electricity at CEIP Gabriela Mistral.

*Table 9. Compilation of heating oil consumption for CEIP Gabriela Mistral.*

| **Heating oil** - CEPSA Invoices | | | | |
|---|---|---|---|---|
| | Volume (L) | Price | Cost (excluding VAT) | with VAT 21%. |
| **Jan-19** | 1000 | 0,59298 | 592,98 | 717,51 |
| **Feb-19** | 1500 | 0,59298 | 889,47 | 1076,26 |
| **Mar-19** | 2000 | 0,64802 | 1296,04 | 1568,21 |
| **Apr-19** | - | - | - | - |
| **May-19** | - | - | - | - |
| **Jun-19** | - | - | - | - |
| **Jul-19** | - | - | - | - |
| **Aug-19** | - | - | - | - |
| **Sep-19** | - | - | - | - |
| **Oct-19** | - | - | - | - |

| **Heating oil** - CEPSA Invoices | | | | |
|---|---|---|---|---|
| **Nov-19** | 2000 | 0,6402 | 1280,40 | 1549,28 |
| **Nov-19** | 1000 | 0,6611 | 661,10 | 799,93 |
| **Dec-19** | - | - | - | - |
| | 2020 | | | |
| **Jan-20** | 2500 | 0,6776 | 1694,00 | 2049,74 |
| **Feb-20** | 2700 | 0,6198 | 1673,46 | 2024,89 |

*Table 10. Compilation of electricity consumption at CEIP Gabriel Mistral.*

| | Electric power - ENDESA | | | | |
|---|---|---|---|---|---|
| | Energy (KWh) | Price (c€) | Cost (exclusive of VAT) taxed | Total cost (€) | Period (days) |
| **Jan-19** | 3508 | 0,127292 | 613,05 | 741,79 | 27 |
| **Feb-19** | 3912 | 0,127004 | 574,35 | 694,96 | 33 |
| **Mar-19** | 3582 | 0,127002 | 803,38 | 972,09 | 26 |
| **Apr-19** | 2888 | 0,133892 | 581,33 | 703,41 | 30 |
| **May-19** | 3593 | 0,134776 | 575,94 | 696,89 | 35 |
| **Jun-19** | 2063 | 0,130257 | 374,13 | 452,7 | 29 |
| **Jul-19** | 1514 | 0,121863 | 337,09 | 407,88 | 34 |
| **Aug-19** | 752 | 0,12234 | 168,32 | 203,72 | 17 |
| **Sep-19** | 4197 | 0,130593 | 682,54 | 825,87 | 45 |
| **Oct-19** | 4043 | 0,130396 | 586,57 | 709,75 | 31 |
| **Nov-19** | 3464 | 0,0954 | 510,34 | 617,51 | 28 |
| **Dec-19** | 2126 | 0,0992 | 395,04 | 478 | 26 |
| | | | 2020 | | |
| **Jan-20** | 3652 | 0,0929 | 562,51 | 680,64 | 31 |
| **Feb-20** | 3065 | 0,0924 | 558,42 | 675,69 | 29 |

**Water management.**

I2.1 Savings in water consumption in irrigation water for green areas in the pilot buildings.

I2.2 Savings in rainwater management.

**Management of green areas.**

I3.1Increased plant and animal biodiversity. I3.2

Number of native plant species.

**Air quality**

I4.1 Carbon dioxide concentration inside the classroom. I4.2 Noise

reduction levels from outside.

I4.3 Number of bioindicator species installed and area covered with these bioindicators.

I4.4 Training in the observation of bioindicator species of contamination.

**Urban regeneration**

I5.1 Energy efficiency measures.

Collection of information in process.

I5.2 Increase in green area.

The following table shows the surface areas related to the project. The school currently has a total area of green areas of 1,049.90 m$^2$ .

*Table 11. Representative surfaces of the school.*

| | Sup. Built per floor (m²) | | Sup. Total Built (m²) | Free Space (m²) | Green areas (m²) | % Green areas | Total plot area (m²) |
|---|---|---|---|---|---|---|---|
| **OPORTO** | P-1 | 412,9 | 1.004,50 | 4.363,30 | 1.049,90 | 24,06 | 5.669,20 |
| | PB | 387,50 | | | | | |
| | P1 | 204,1 | | | | | |

**Governance and participation**

I6.1 Citizen perception of urban nature.

The indicators of this challenge (I6.2, I6.3 and I6.4) related to new learning policies, strategic plans, open participatory processes and other actions carried out with user participation are initially considered 0 and actions of this type promoted by the project or arising in its context will be counted.

**Social cohesion**

The indicator corresponding to this challenge, I7.1 No. of agreements and disagreements will initially be considered as 0 and agreements or disagreements within the scope of the project promoted by the actions of the project will be counted.

**Public health and welfare**

I8.1 Reduction in the number of absences and sick leaves of students and teachers.

Indicator I.8.2. Use of the NBS by users will be analyzed after implementation by means of specific questionnaires for each school and the results will then be evaluated.

**Economic opportunities and employment**

Indicators I9.1 Number of jobs created and I9.2 Creation of new capacities in self-employed and businesses in the area related to the NBS will be analyzed after the implementations through specific questionnaires for each school and then the results will be evaluated.

I9.3 Reduction of absenteeism among school personnel.

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# 8. ANNEX I. CLIMATIC DATA.

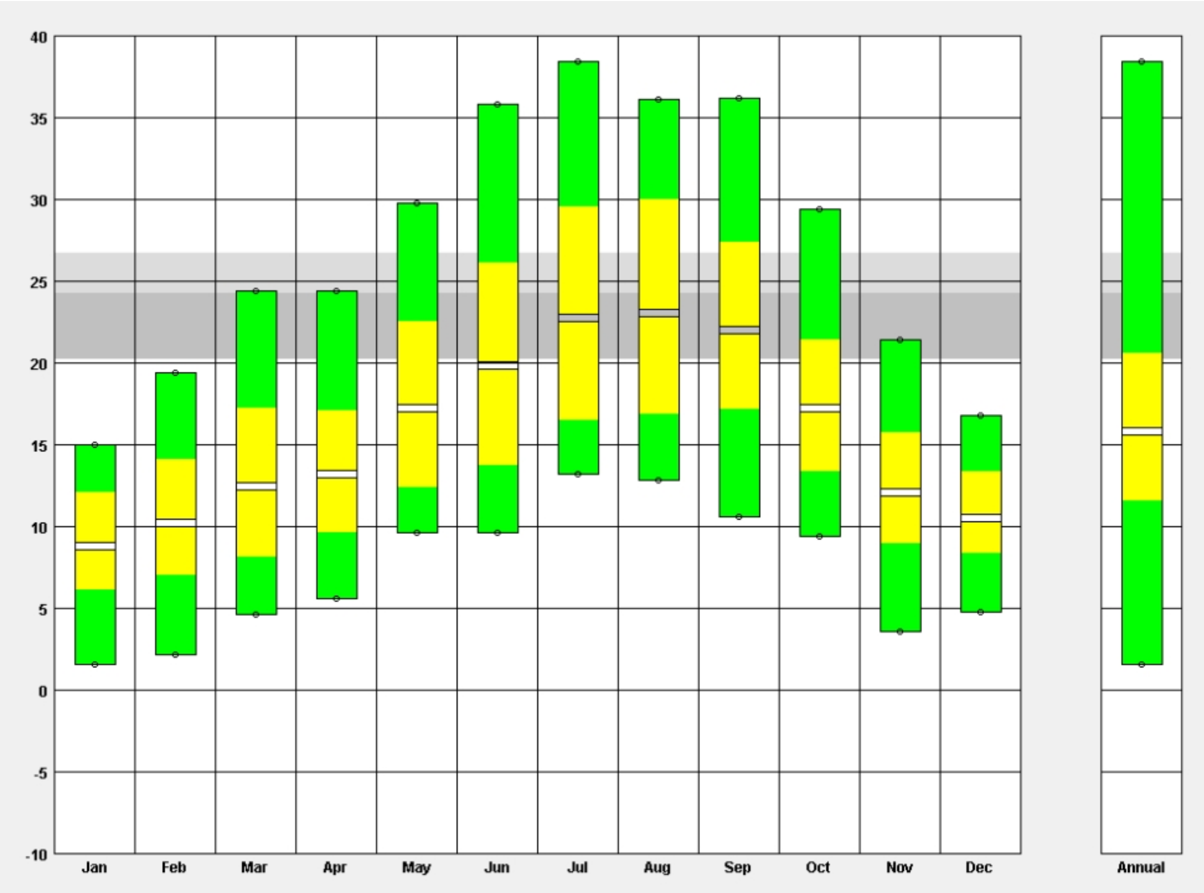
## 8.1 Évora

Geographical coordinates:
38.6º North // 7.9º West

Table of general climatic data

| MONTHLY MEANS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Global Horiz Radiation (Avg Hourly) | 232 | 276 | 404 | 405 | 479 | 483 | 518 | 499 | 410 | 321 | 230 | 198 | Wh/sq.m |
| Direct Normal Radiation (Avg Hourly) | 294 | 242 | 454 | 267 | 390 | 384 | 492 | 489 | 360 | 315 | 210 | 222 | Wh/sq.m |
| Diffuse Radiation (Avg Hourly) | 111 | 152 | 136 | 223 | 195 | 196 | 151 | 147 | 179 | 153 | 133 | 114 | Wh/sq.m |
| Global Horiz Radiation (Max Hourly) | 538 | 665 | 846 | 940 | 1002 | 1003 | 996 | 956 | 859 | 750 | 560 | 461 | Wh/sq.m |
| Direct Normal Radiation (Max Hourly) | 849 | 797 | 922 | 901 | 931 | 905 | 909 | 915 | 867 | 882 | 771 | 808 | Wh/sq.m |
| Diffuse Radiation (Max Hourly) | 282 | 309 | 431 | 664 | 664 | 690 | 479 | 467 | 428 | 365 | 312 | 240 | Wh/sq.m |
| Global Horiz Radiation (Avg Daily Total) | 2237 | 2891 | 4757 | 5292 | 6770 | 7077 | 7452 | 6719 | 5040 | 3532 | 2292 | 1852 | Wh/sq.m |
| Direct Normal Radiation (Avg Daily Total) | 2840 | 2527 | 5324 | 3492 | 5513 | 5631 | 7077 | 6579 | 4428 | 3470 | 2106 | 2077 | Wh/sq.m |
| Diffuse Radiation (Avg Daily Total) | 1072 | 1598 | 1609 | 2916 | 2763 | 2871 | 2184 | 1981 | 2188 | 1676 | 1321 | 1067 | Wh/sq.m |
| Global Horiz Illumination (Avg Hourly) | 25016 | 29936 | 43475 | 44239 | 52053 | 52621 | 56292 | 54415 | 44837 | 35044 | 25028 | 21437 | lux |
| Direct Normal Illumination (Avg Hourly) | 26778 | 23067 | 43915 | 25628 | 38033 | 37495 | 48520 | 48065 | 34190 | 29291 | 19452 | 19638 | lux |
| Dry Bulb Temperature (Avg Monthly) | 8 | 10 | 12 | 13 | 17 | 19 | 22 | 23 | 21 | 17 | 12 | 10 | degrees C |
| Dew Point Temperature (Avg Monthly) | 5 | 4 | 5 | 8 | 8 | 10 | 12 | 12 | 12 | 11 | 6 | 7 | degrees C |
| Relative Humidity (Avg Monthly) | 81 | 68 | 65 | 74 | 61 | 61 | 58 | 55 | 61 | 72 | 72 | 81 | percent |
| Wind Direction (Monthly Mode) | 330 | 60 | 340 | 300 | 320 | 320 | 320 | 320 | 330 | 180 | 350 | 340 | degrees |
| Wind Speed (Avg Monthly) | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | m/s |
| Ground Temperature (Avg Monthly of 3 Depths) | 11 | 10 | 11 | 11 | 14 | 17 | 19 | 20 | 20 | 18 | 16 | 13 | degrees C |

Monthly maximum and minimum temperatures




Maximum comfort T: Summer 27ºC; Winter 24ºC Green:

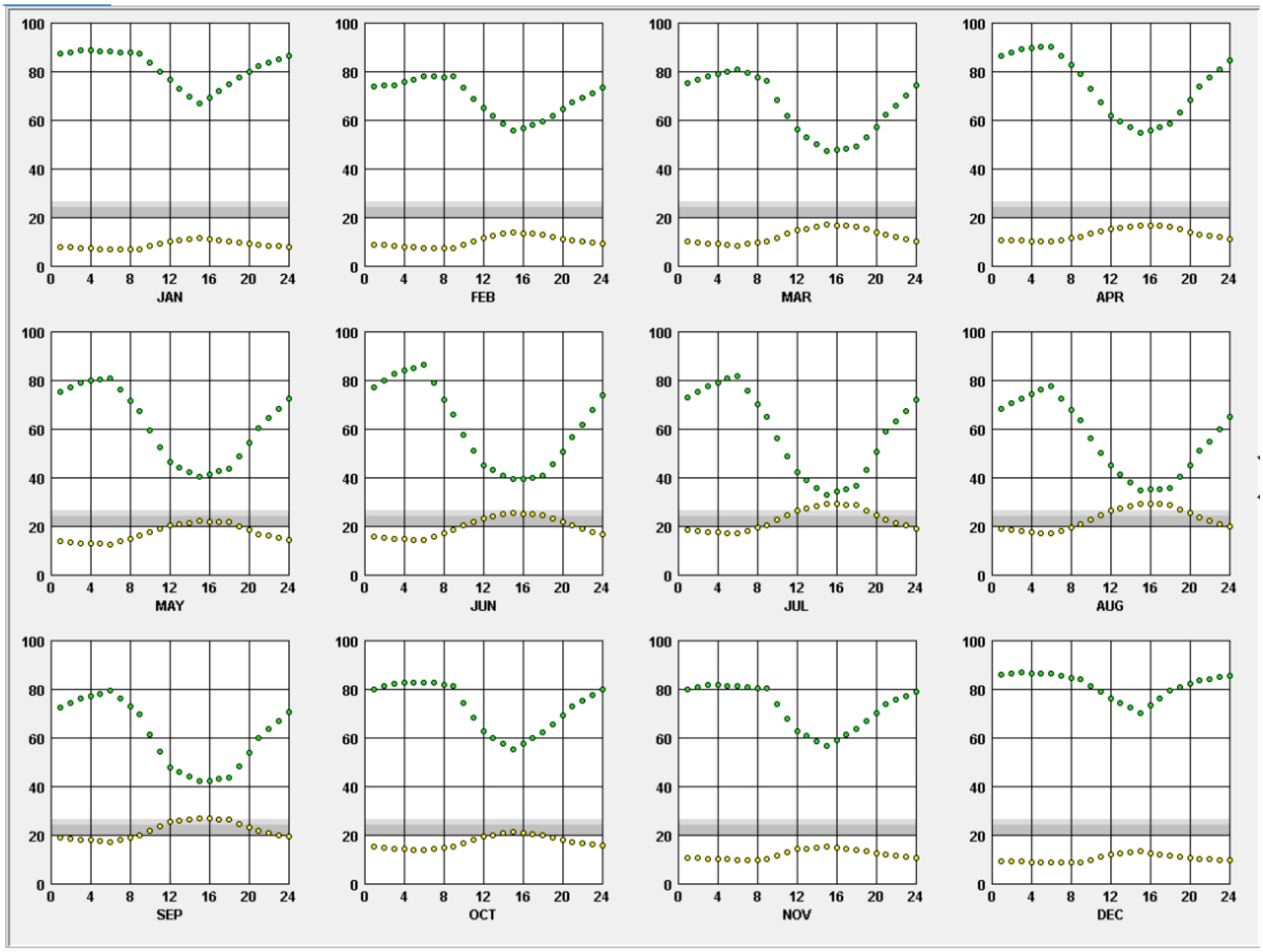
Maximum and minimum design temperatures.

Yellow: Maximum and minimum temperatures with average data.

White: Average temperatures.

Between the months of May to October, inclusive, daily maximum temperatures exceed 27 degrees Celsius. In contrast to the climate of Porto, the climate of Evora is much hotter, exceeding 35 degrees Celsius from June to September. These data are relevant for the purpose of controlling overheating in this period.

Hourly temperature and humidity on a typical day/month.

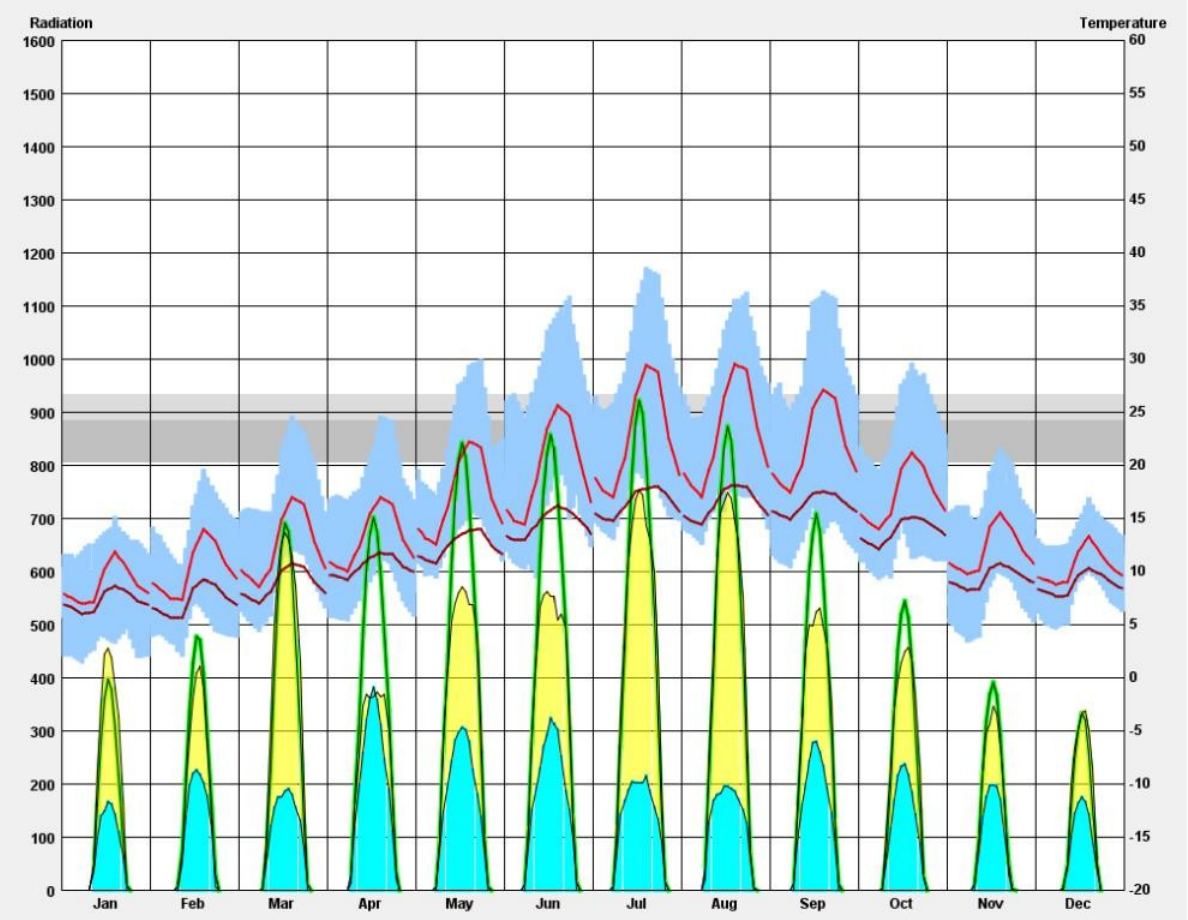



Green: Relative humidity

Yellow: Dry bulb temperature

As the graphs show, the climate in Évora is characterized by being drier than in Porto. In the hot months, from May to September, the relative humidity in the central hours of the day drops to 40%.

Radiation




Radiation (Wh/m$^2$ ): Incident radiation in normal plane for a typical day of each month.

Blue: Diffuse

Yellow: Direct normal Green:

Total horizontal plane

Temperature:

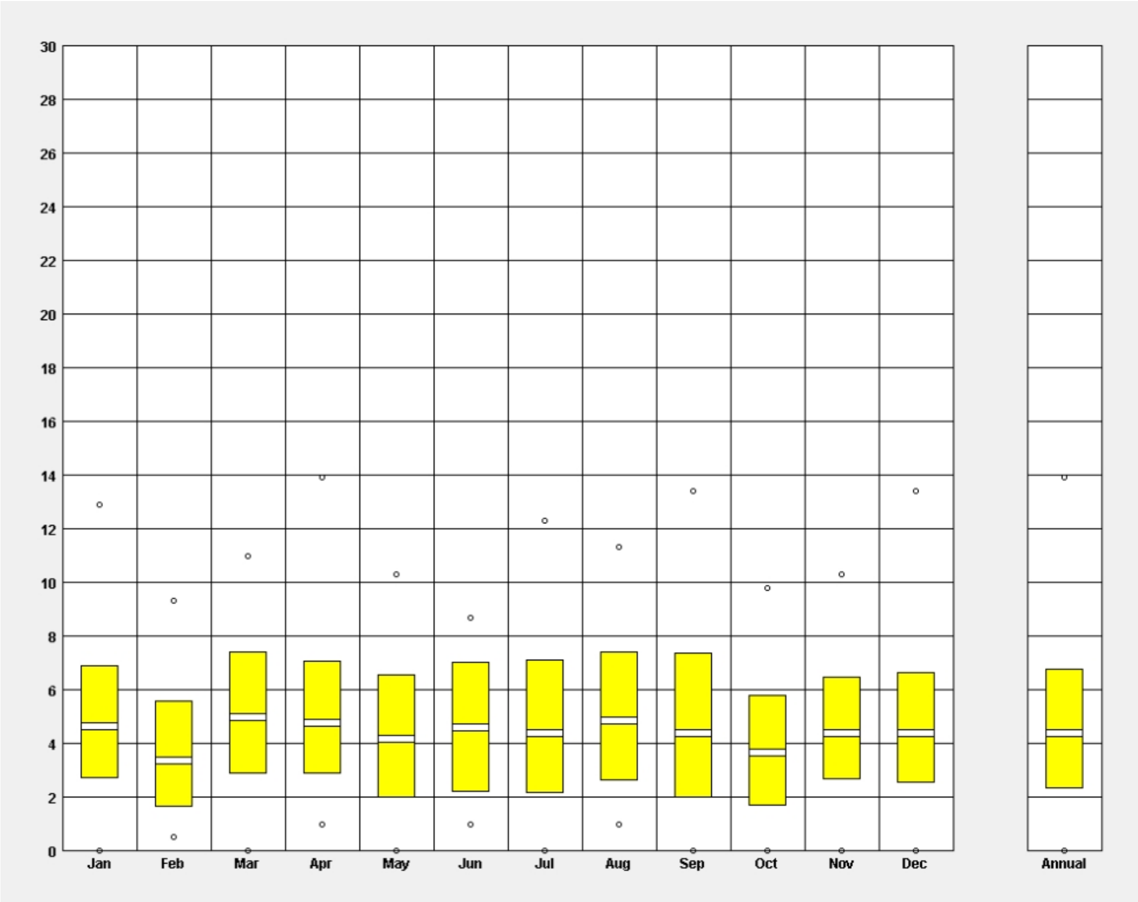
Red line: Dry bulb temperature. Hourly average

Dark red line: Wet bulb temperature. Blue hourly mean: Dry bulb

temperature. All hours

A higher solar incidence, together with the drier continental climate, is reflected in higher temperatures than in Oporto. Between the months of May and October, daily temperatures are in excess of 30ºC.

Wind

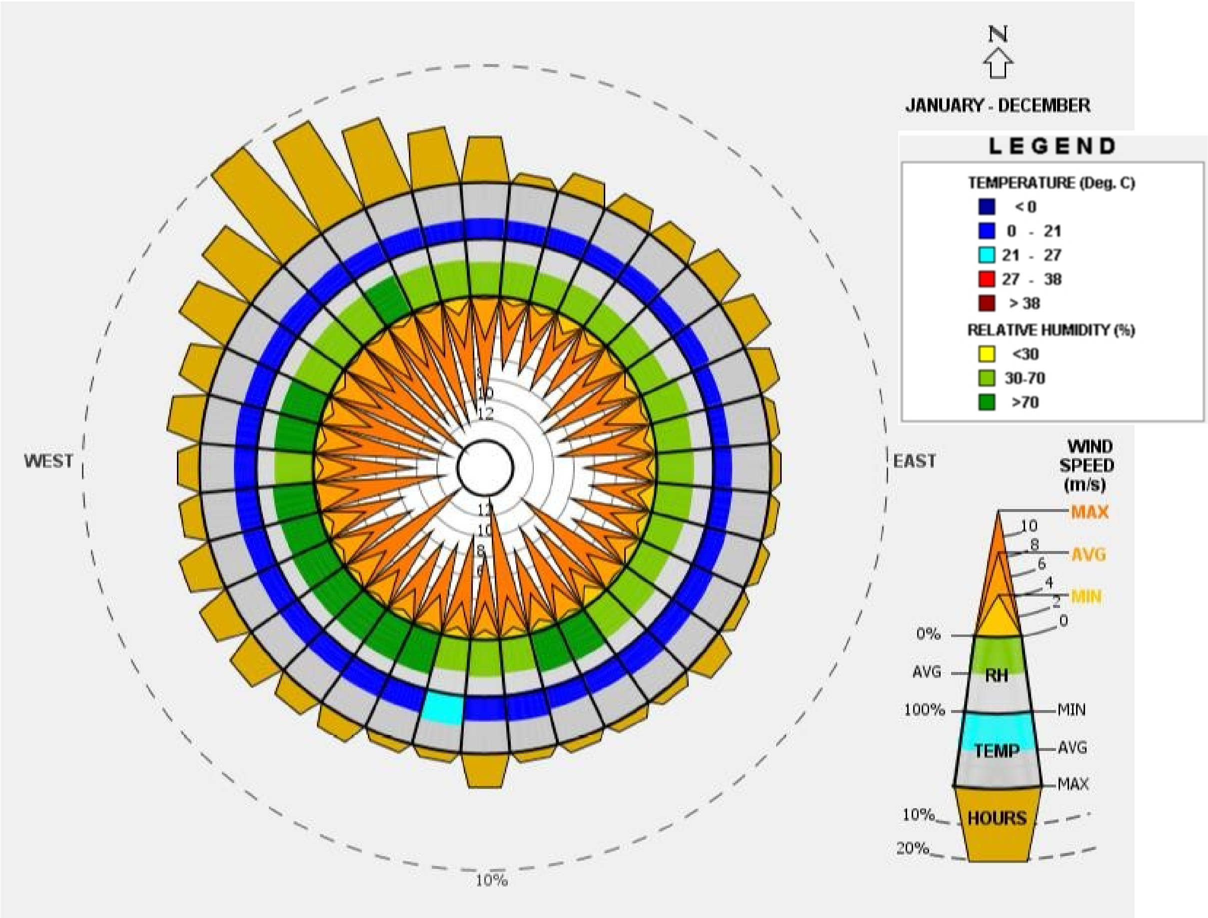



White: Average wind speed value for day type month (m/s) Yellow: Average

maximum and average minimum values of wind speed

Homogeneous wind speeds are observed among the stations. The average speed, around 4 m/s, is slightly higher than the data found for the climate of Porto.

Wind rose.




The wind rose indicates the direction of the prevailing winds, with their average, minimum and maximum speeds, and with information on the associated temperature and humidity parameters.

This climate is dominated by northwesterly winds with average speeds of 6 m/s for this orientation.

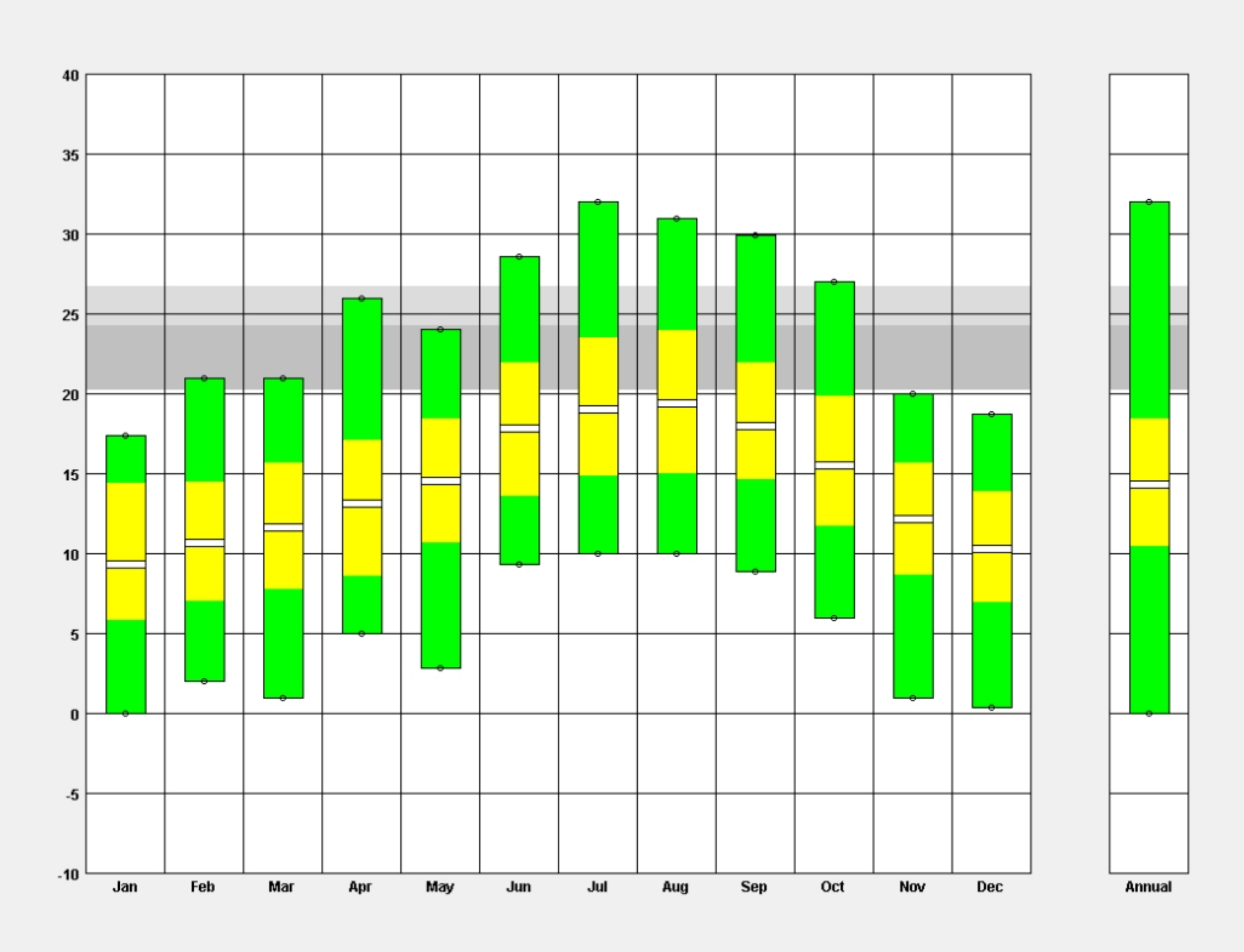
## 8.2 Porto

Geographical Coordinates: 41.5º North // 8.6º West

Table of Contents of data general climatic

| MONTHLY MEANS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Global Horiz Radiation (Avg Hourly) | 187 | 253 | 346 | 425 | 443 | 474 | 457 | 450 | 374 | 293 | 181 | 164 | Wh/sq.m |
| Direct Normal Radiation (Avg Hourly) | 200 | 273 | 352 | 372 | 381 | 420 | 417 | 415 | 356 | 315 | 166 | 211 | Wh/sq.m |
| Diffuse Radiation (Avg Hourly) | 109 | 125 | 138 | 161 | 165 | 157 | 143 | 153 | 148 | 128 | 110 | 88 | Wh/sq.m |
| Global Horiz Radiation (Max Hourly) | 449 | 598 | 816 | 907 | 961 | 976 | 961 | 930 | 842 | 719 | 493 | 421 | Wh/sq.m |
| Direct Normal Radiation (Max Hourly) | 656 | 815 | 895 | 824 | 914 | 880 | 907 | 889 | 899 | 849 | 659 | 729 | Wh/sq.m |
| Diffuse Radiation (Max Hourly) | 274 | 299 | 383 | 460 | 506 | 436 | 455 | 485 | 466 | 337 | 292 | 283 | Wh/sq.m |
| Global Horiz Radiation (Avg Daily Total) | 1765 | 2614 | 4089 | 5615 | 6360 | 7077 | 6686 | 6129 | 4615 | 3195 | 1758 | 1495 | Wh/sq.m |
| Direct Normal Radiation (Avg Daily Total) | 1881 | 2806 | 4174 | 4932 | 5459 | 6278 | 6092 | 5663 | 4399 | 3455 | 1610 | 1921 | Wh/sq.m |
| Diffuse Radiation (Avg Daily Total) | 1024 | 1293 | 1631 | 2122 | 2379 | 2355 | 2108 | 2089 | 1815 | 1383 | 1068 | 804 | Wh/sq.m |
| Global Horiz Illumination (Avg Hourly) | 20278 | 27455 | 37548 | 46111 | 48402 | 51749 | 50348 | 49497 | 41206 | 31961 | 19753 | 17804 | lux |
| Direct Normal Illumination (Avg Hourly) | 17800 | 25380 | 33924 | 36437 | 37302 | 41274 | 41139 | 40510 | 34409 | 29633 | 15046 | 18477 | lux |
| Dry Bulb Temperature (Avg Monthly) | 9 | 10 | 11 | 13 | 14 | 17 | 18 | 19 | 18 | 15 | 12 | 10 | degrees C |
| Dew Point Temperature (Avg Monthly) | 5 | 7 | 7 | 8 | 10 | 13 | 15 | 14 | 14 | 11 | 8 | 7 | degrees C |
| Relative Humidity (Avg Monthly) | 80 | 81 | 78 | 76 | 78 | 75 | 80 | 76 | 81 | 76 | 80 | 82 | percent |
| Wind Direction (Monthly Mode) | 110 | 90 | 90 | 350 | 300 | 320 | 300 | 0 | 190 | 170 | 110 | 100 | degrees |
| Wind Speed (Avg Monthly) | 2 | 4 | 3 | 3 | 4 | 1 | 3 | 2 | 1 | 3 | 3 | 1 | m/s |
| Ground Temperature (Avg Monthly of 3 Depths) | 11 | 10 | 11 | 11 | 13 | 15 | 16 | 17 | 17 | 16 | 14 | 12 | degrees C |

Monthly maximum and minimum temperatures




Maximum comfort T: Summer 27ºC; Winter 24ºC Green:

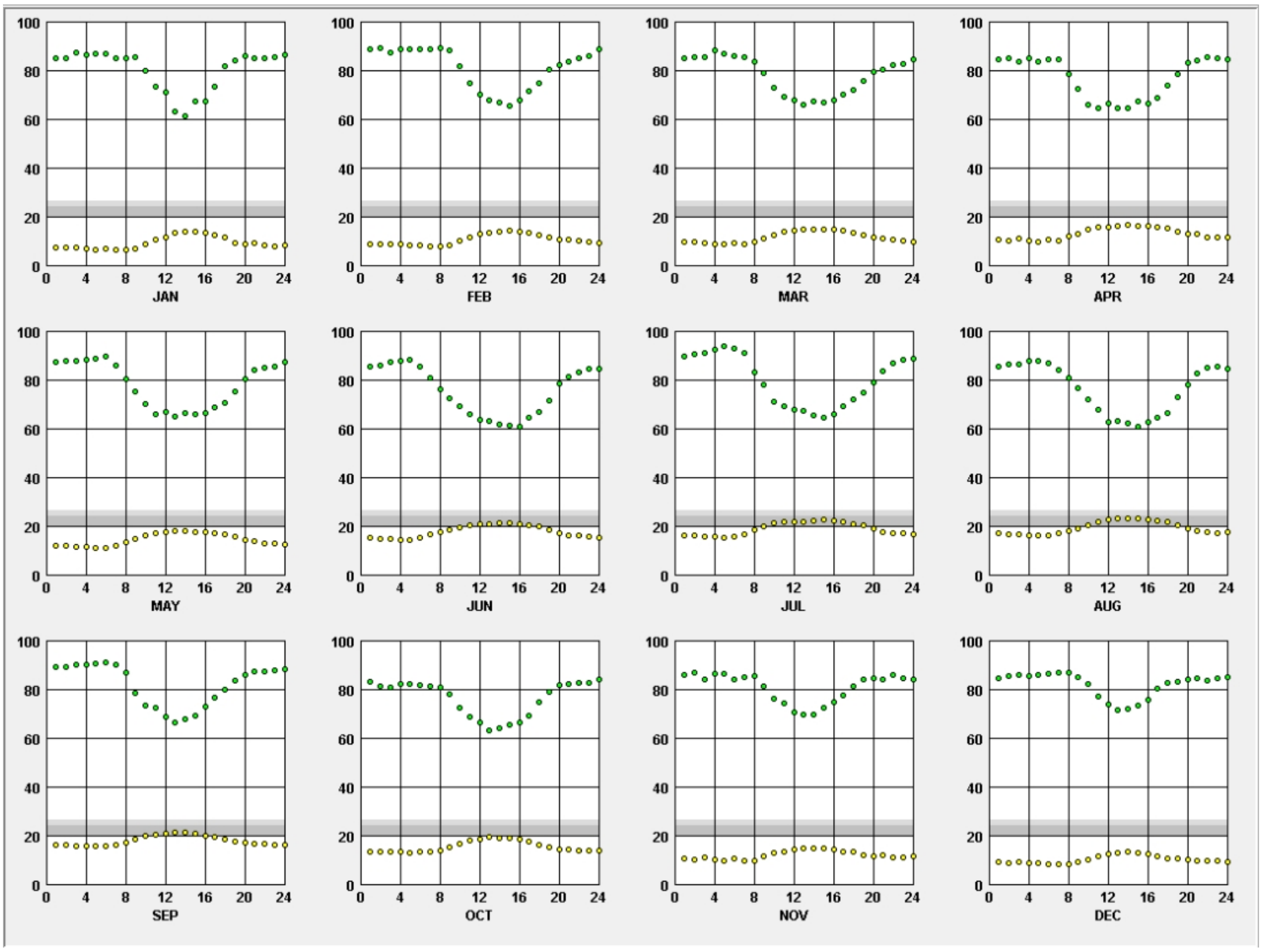
Maximum and minimum design temperatures.

Yellow: Maximum and minimum temperatures with average data.

White: Average temperatures.

Between the months of June and September, inclusive, daily maximum temperatures exceed 27 degrees Celsius.

Hourly temperature and humidity on a typical day/month.

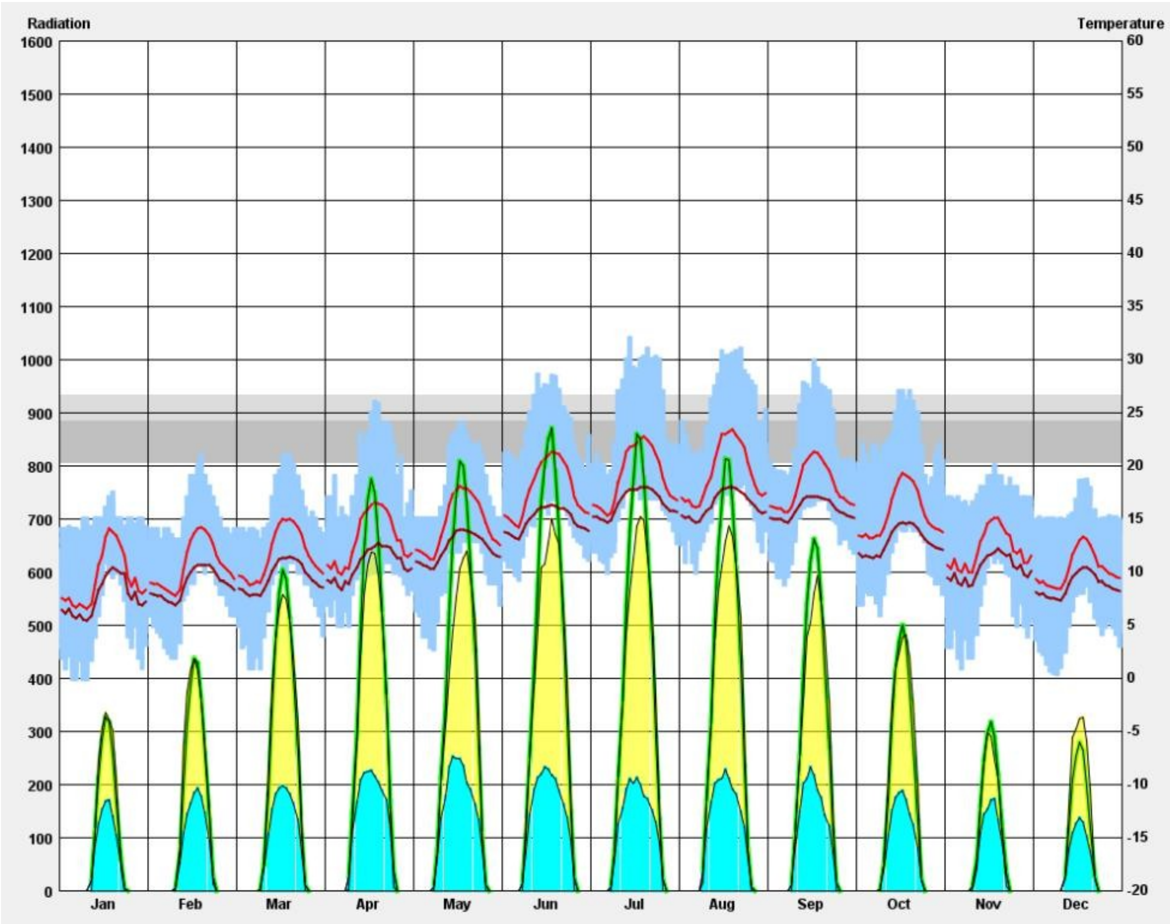



Green: Relative humidity

Yellow: Dry bulb temperature

There is a high degree of ambient humidity ranging between 60 and 90%.

Radiation




Radiation (Wh/m$^2$ ): Incident radiation in normal plane for a typical day of each month.

Blue: Diffuse

Yellow: Direct normal Green:

Total horizontal plane

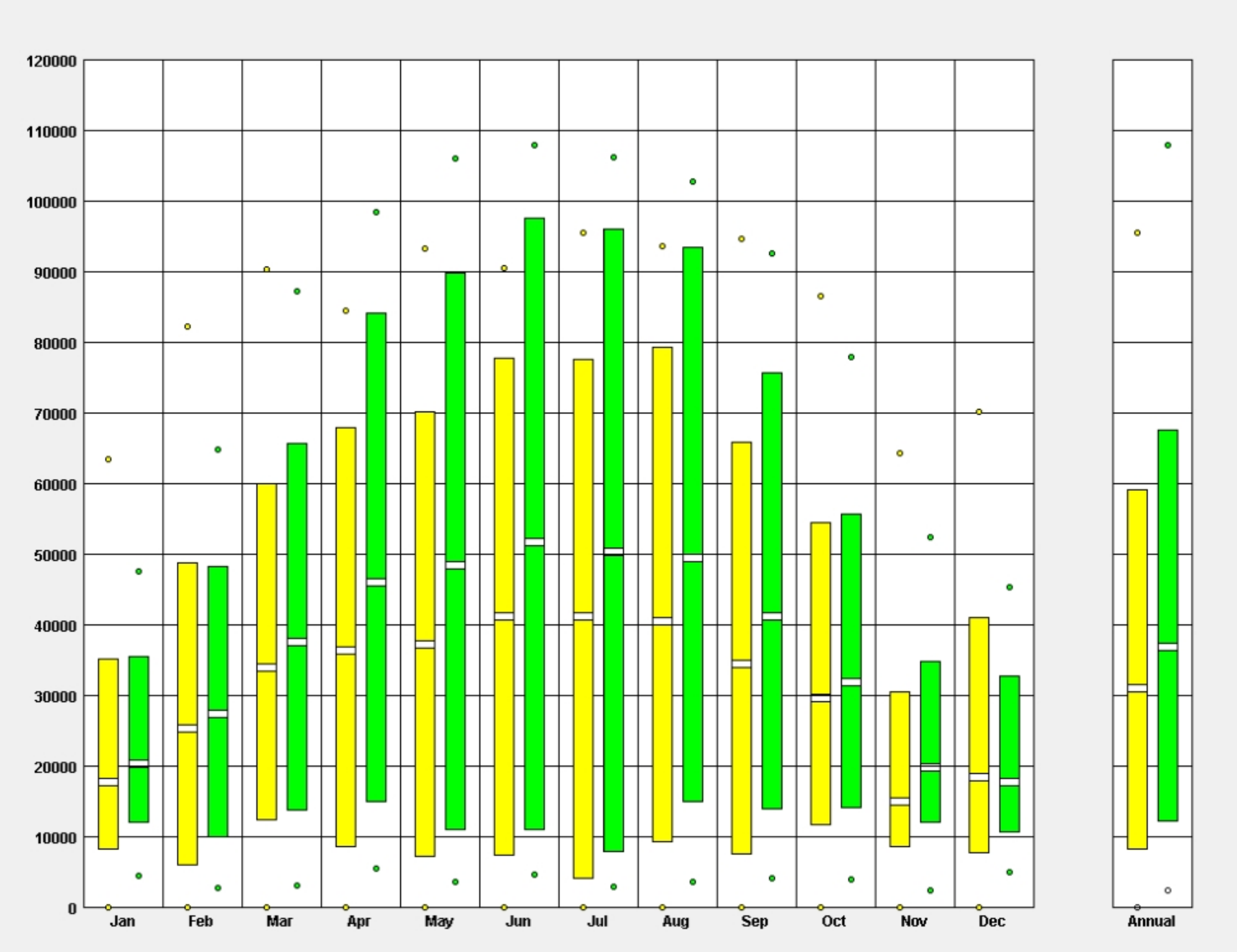
Temperature:

Red line: Dry bulb temperature. Hourly average

Dark red line: Wet bulb temperature. Blue hourly mean: Dry bulb

temperature. All hours

Between the months of June and October, daily temperatures exceed 27ºC. Illumination

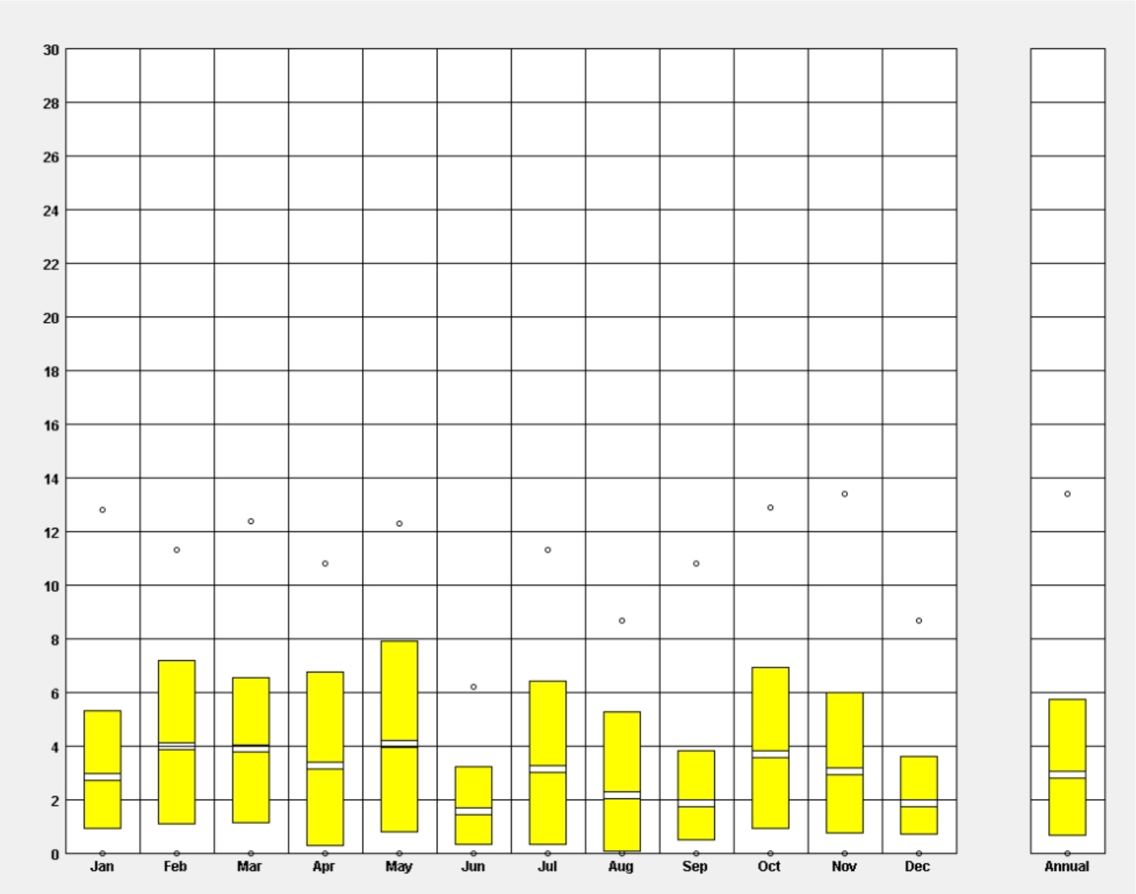



Yellow: Hourly illumination. Normal direct (lux). Average // Average maximum value // Average minimum value.

Green: Hourly illumination. Global horizontal (lux). Average // Average maximum value // Average minimum value.

These values indicate the amount of natural lighting that can be captured for interior lighting control. Their use implies reductions in energy expenditure on artificial lighting. However, an inadequate use can lead to excessive solar gains and therefore to interior overheating in undesired months.

Wind

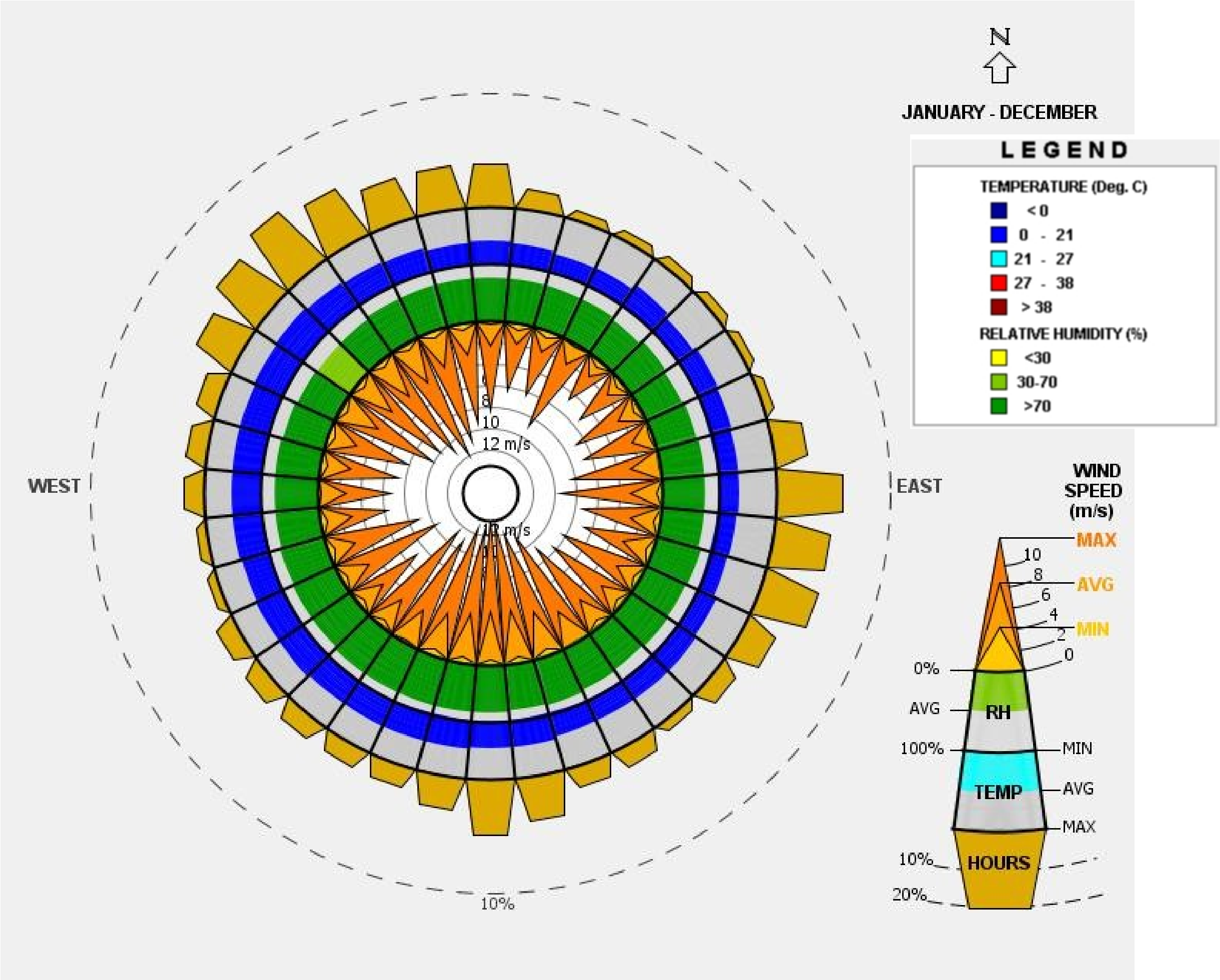



White: Average wind speed value for day type month (m/s) Yellow: Average

maximum and average minimum values of wind speed

Warmer months have lower wind speeds. This must be taken into account for the design of the induced natural ventilation action.

Wind rose.




The wind rose indicates the direction of the prevailing winds, with their average, minimum and maximum speeds, and with information on the associated temperature and humidity parameters.

Predominantly northwesterly and easterly winds with average speeds of 4 m/s.

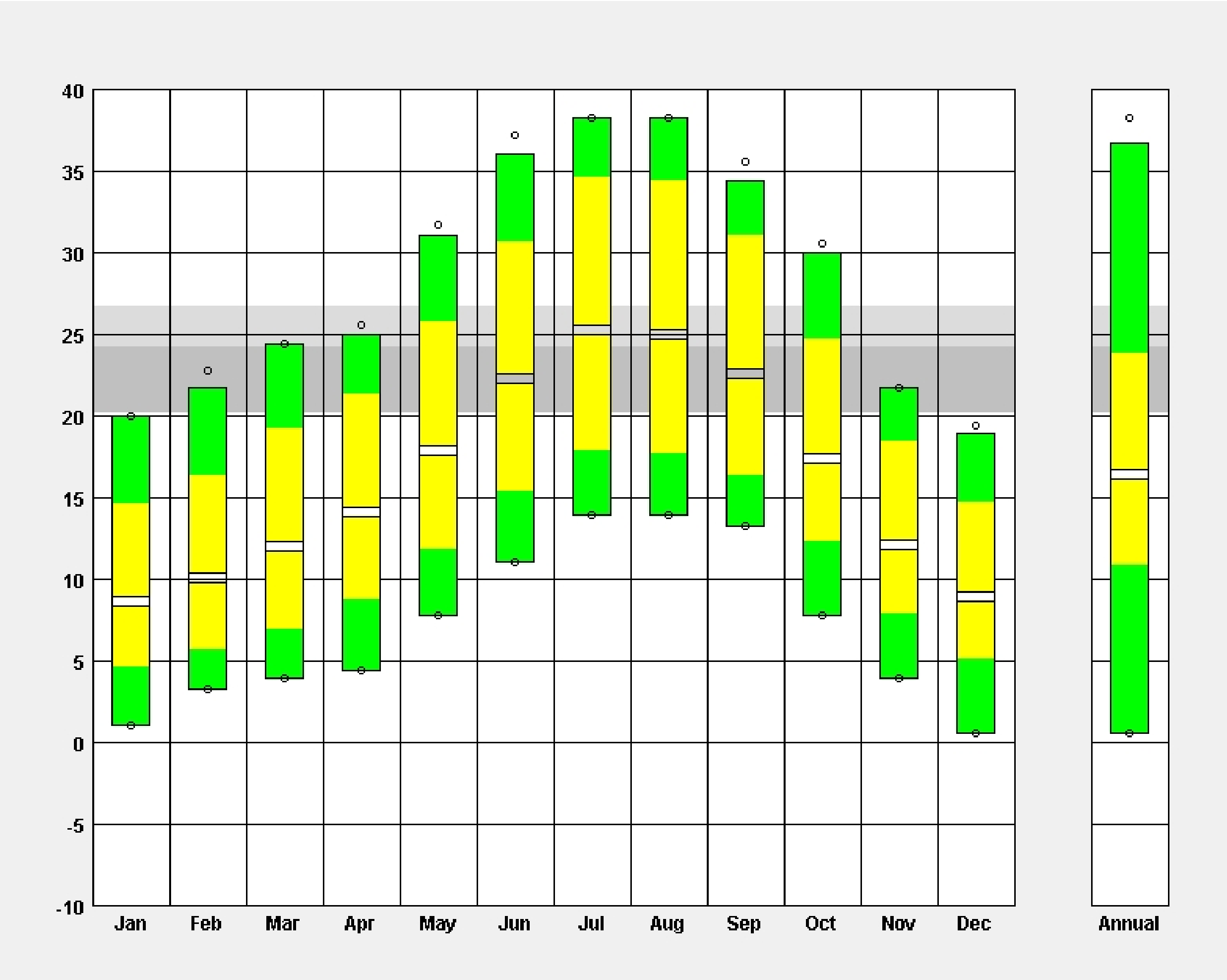
## 8.3 Solana de los Barros (Badajos)

Geographic coordinates:
38.9º North // 6.9º West

Table of general climatic data

| MONTHLY MEANS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Global Horiz Radiation (Avg Hourly) | 230 | 291 | 362 | 409 | 466 | 483 | 529 | 509 | 424 | 342 | 261 | 212 | Wh/sq.m |
| Direct Normal Radiation (Avg Hourly) | 274 | 326 | 376 | 336 | 418 | 430 | 537 | 529 | 471 | 394 | 336 | 273 | Wh/sq.m |
| Diffuse Radiation (Avg Hourly) | 118 | 135 | 152 | 185 | 173 | 170 | 147 | 152 | 137 | 137 | 117 | 105 | Wh/sq.m |
| Global Horiz Radiation (Max Hourly) | 533 | 700 | 810 | 933 | 974 | 974 | 971 | 940 | 858 | 744 | 558 | 479 | Wh/sq.m |
| Direct Normal Radiation (Max Hourly) | 788 | 858 | 889 | 911 | 899 | 883 | 892 | 880 | 858 | 845 | 794 | 769 | Wh/sq.m |
| Diffuse Radiation (Max Hourly) | 252 | 340 | 407 | 419 | 415 | 474 | 444 | 399 | 388 | 349 | 266 | 228 | Wh/sq.m |
| Global Horiz Radiation (Avg Daily Total) | 2219 | 3064 | 4260 | 5355 | 6606 | 7090 | 7635 | 6870 | 5212 | 3741 | 2590 | 1978 | Wh/sq.m |
| Direct Normal Radiation (Avg Daily Total) | 2642 | 3441 | 4413 | 4415 | 5939 | 6327 | 7742 | 7154 | 5771 | 4297 | 3335 | 2553 | Wh/sq.m |
| Diffuse Radiation (Avg Daily Total) | 1134 | 1413 | 1793 | 2417 | 2448 | 2495 | 2131 | 2051 | 1683 | 1506 | 1161 | 985 | Wh/sq.m |
| Global Horiz Illumination (Avg Hourly) | | | | | | | | | | | | | lux |
| Direct Normal Illumination (Avg Hourly) | | | | | | | | | | | | | lux |
| Dry Bulb Temperature (Avg Monthly) | 8 | 10 | 12 | 14 | 17 | 22 | 25 | 24 | 22 | 17 | 12 | 8 | degrees C |
| Dew Point Temperature (Avg Monthly) | 4 | 4 | 5 | 7 | 9 | 11 | 12 | 12 | 11 | 10 | 8 | 5 | degrees C |
| Relative Humidity (Avg Monthly) | 79 | 68 | 68 | 68 | 60 | 54 | 50 | 49 | 54 | 66 | 80 | 81 | percent |
| Wind Direction (Monthly Mode) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | degrees |
| Wind Speed (Avg Monthly) | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | m/s |
| Ground Temperature (Avg Monthly of 3 Depths) | 10 | 11 | 12 | 14 | 18 | 20 | 21 | 21 | 19 | 16 | 13 | 11 | degrees C |

Monthly maximum and minimum temperatures




Maximum comfort T: Summer 27ºC; Winter 24ºC Green:

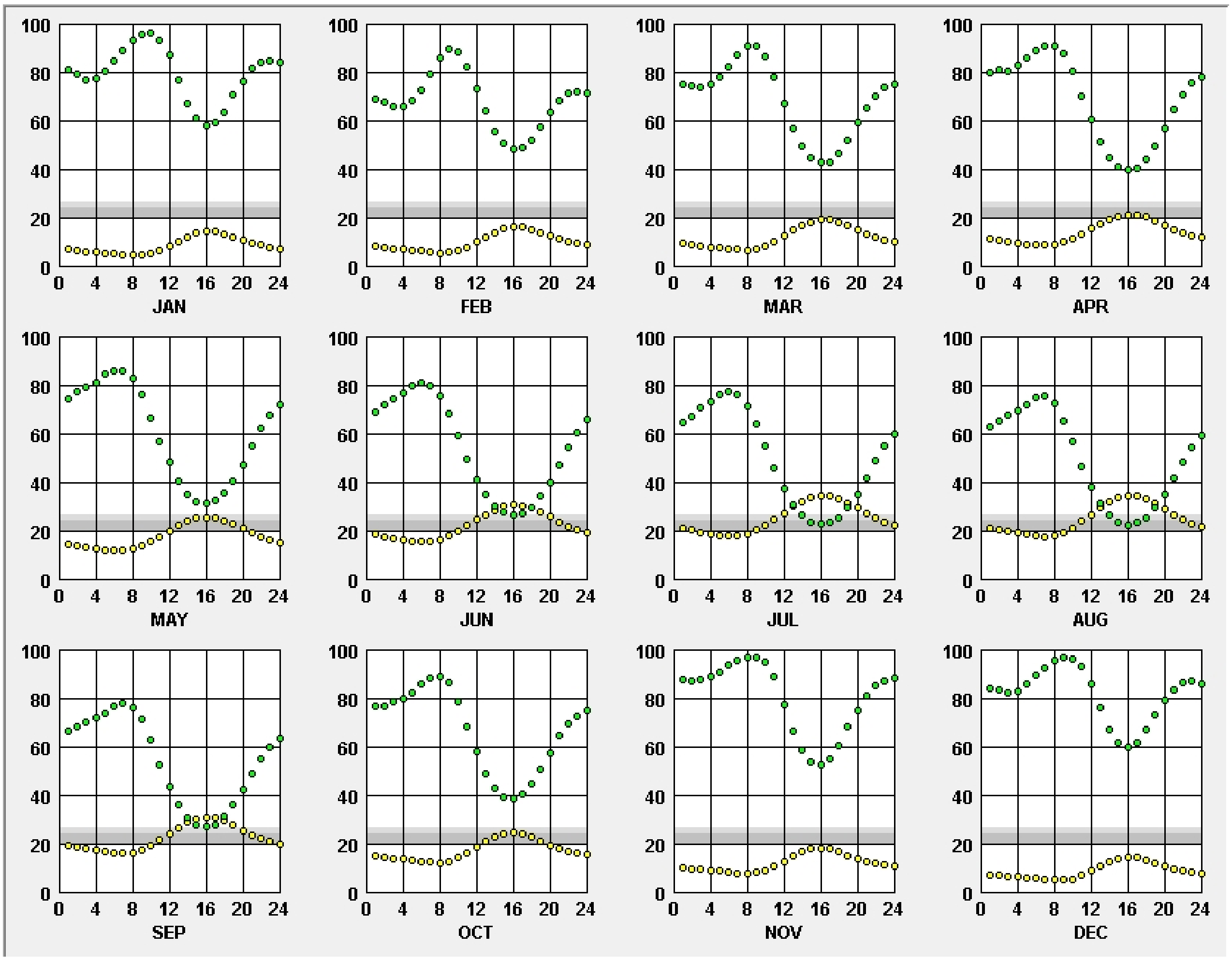
Maximum and minimum design temperatures.

Yellow: Maximum and minimum temperatures with average data.

White: Average temperatures.

Between the months of May to October, inclusive, daily maximum temperatures exceeding 27 degrees Celsius are observed. Being a climate similar to that of Évora, slightly higher temperatures are observed in the warm months, exceeding 35 between the months of June to September.

Hourly temperature and humidity on a typical day/month.

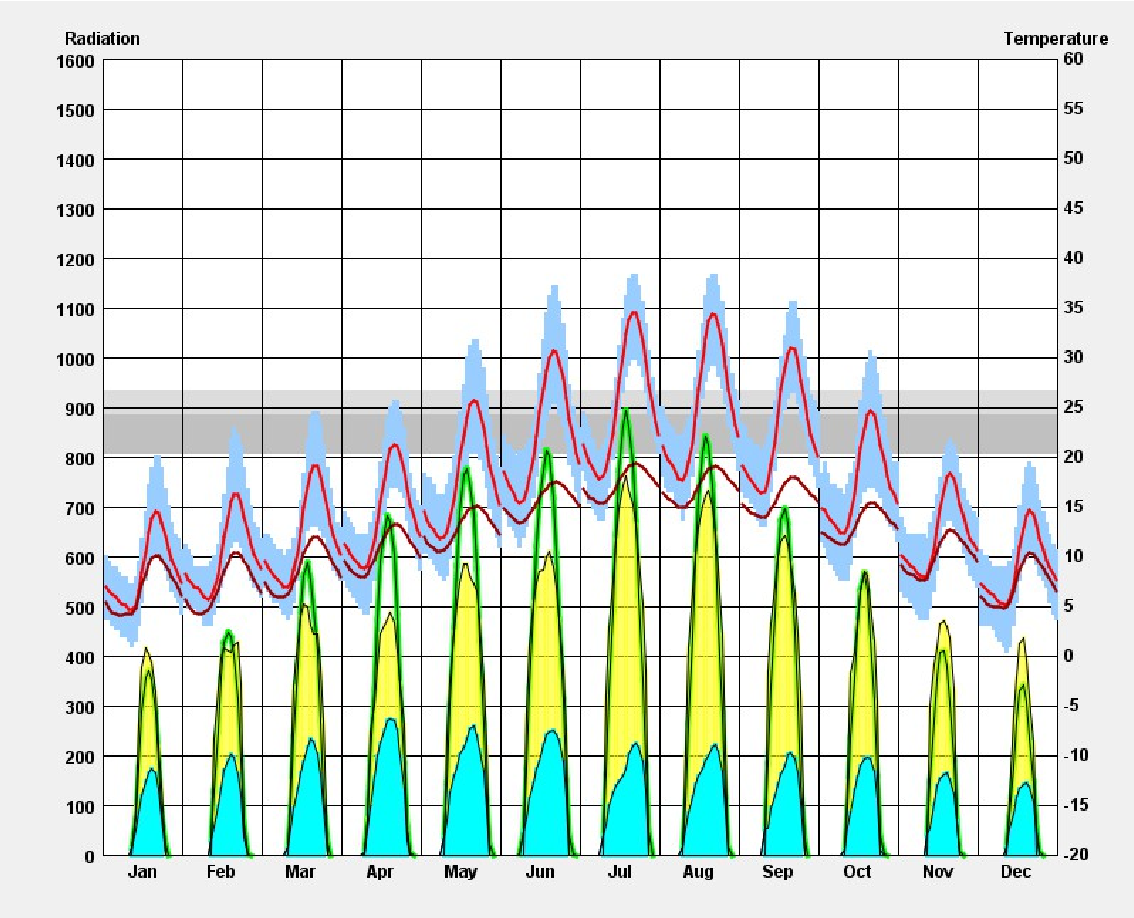



Green: Relative humidity

Yellow: Dry bulb temperature

The high temperatures in the summer months and the dry climate result in relative humidity below 40% from May to October.

Radiation




Radiation (Wh/m$^2$ ): Incident radiation in normal plane for a typical day of each month.

Blue: Diffuse

Yellow: Direct normal Green:

Total horizontal plane

Temperature:

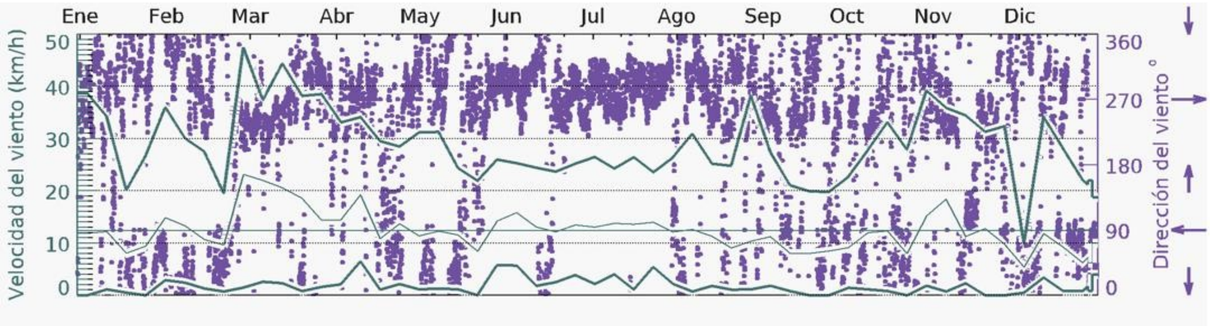
Red line: Dry bulb temperature. Hourly average

Dark red line: Wet bulb temperature. Blue hourly mean: Dry bulb

temperature. All hours

The solar incidence is similar to the location of Évora. However, the temperatures reached are higher, with similar maximum and average records.

Wind




Wind speed data with orientations. https://my.meteoblue.com/