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

Deliverable: Help document for "Prototype Design".

03- Incidence solar y estimate of solar protections

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Solar indecency and sunscreen estimation

1. OBJECTIVE

In this document, calculations are made to estimate the size of the solar protection for façade openings based on the solar incidence in each of the latitudes of the schools.

Based on climate data (help document 01-Climate Data), and bioclimatic strategy guidelines (help document 02-Bioclimatic Strategies).

The results are given in the form of solar incidence angles to be protected for the required months according to each region. It is specified for South, East and West orientations.

The data are valid as an aid for the dimensioning of the protruding bodies of the prototypes. However, for the final dimensioning it is necessary to adjust for each specific solution defining the size of the openings to be protected and the exact position of the prototype with respect to the opening and the facade.

2. SOLAR CALCULATION

Proceed as follows:

a) Psychometric abacuses (Givoni, 1998) of bioclimatic strategies are used to define the protection needs for each location according to comfort parameters. The temporal window of protection will be delimited by the months in which solar gain is not required and those in which solar gain is required again. It should be borne in mind that summer protection, if oversized, can adversely affect winter conditions by preventing radiation from providing the energy needed for passive heating. The sizing, therefore, must be readjusted so as not to reduce the comfort conditions in winter. These calculations will be made by means of energy simulation programs.

b) Subsequently, cylindrical projection solar charts are used to study the daily solar trajectories, over a whole year, for the locations of Oporto and Badajoz, considering that Évora has practically identical features to Badajoz with respect to solar incidence.

The desired months of protection are defined according to the data obtained from documents 1 and 2 (support documents: 01-Climate data; 02-Bioclimatic strategies).

c) Finally, protection angle masks are applied to define the incident path to be avoided with horizontal cantilevers.

Note on solar and local time. In Spain, the current daylight saving time is the sum of 2 hours with respect to UTC time coordinates. In Portugal the difference in daylight saving time is 1 hour.

2.1. Porto

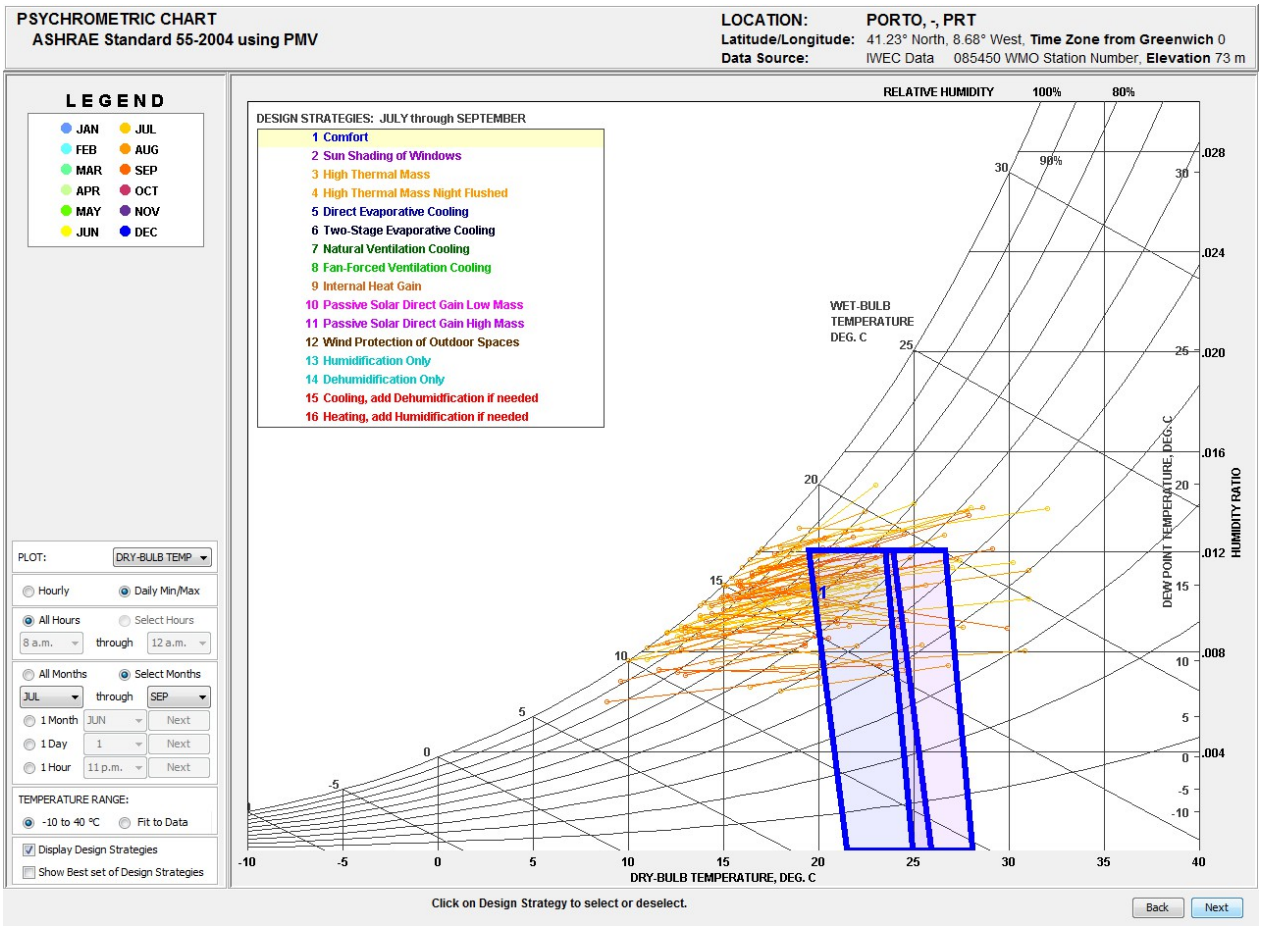


Figure 1. Representation of temperature evolution (line from minimum to maximum) from June to September.

This psychometric abacus shows in the two rectangles the comfort regions (in temperature and humidity). On it are drawn the lines of maximum and minimum for each day of the selected months. In Porto, the study has been limited to the months in which the lines exceed the comfort region for summer, from June to September, both included.

SOUTH FACADE

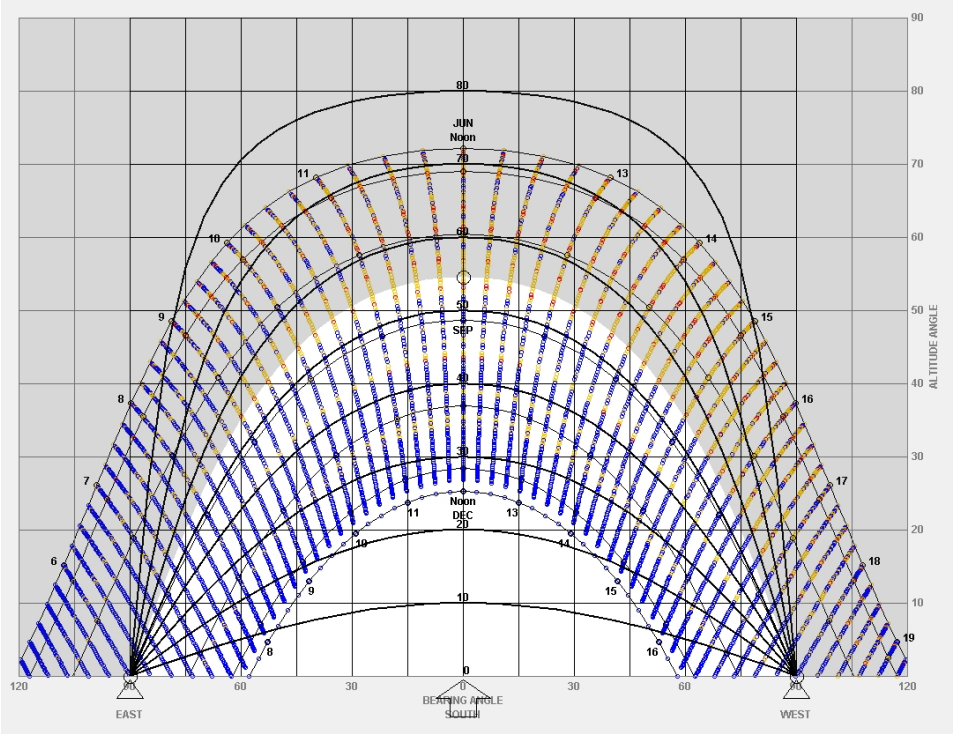


Figure 2. Cylindrical solar chart for Oporto from June to December + solar mask at 55º angle.

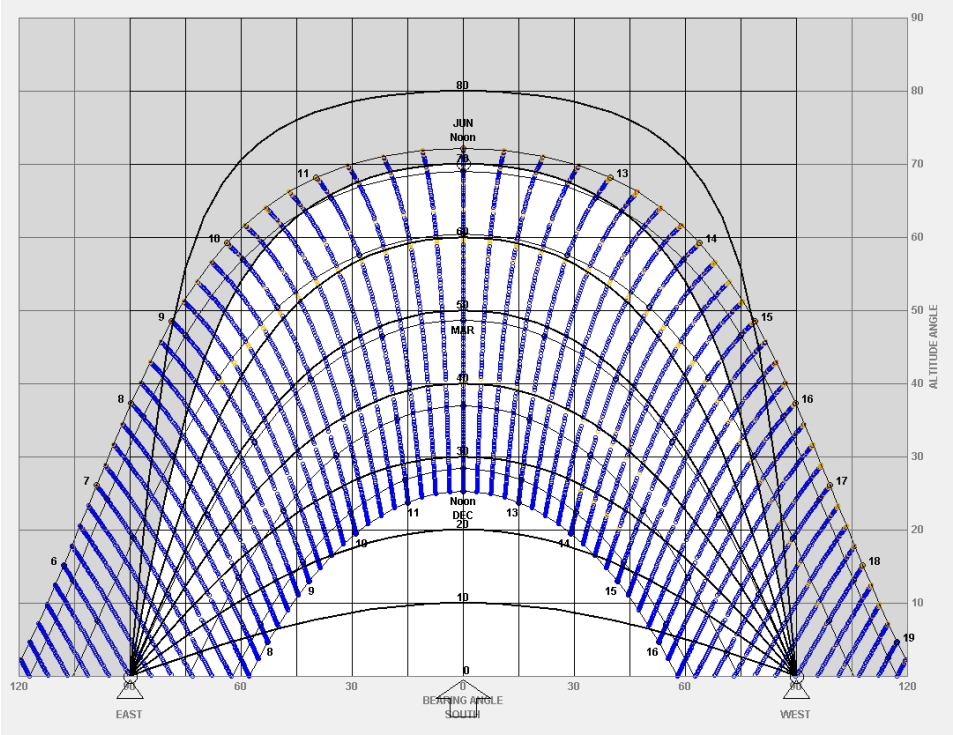


Figure 3. Cylindrical solar chart for Oporto from December to June + solar mask at an angle of 70º.

Figure 2 and Figure 3 show the cylindrical solar charts for the two periods of the year, June to December and December to June. Each month is defined by an east-west curved solar trajectory with the sunrise and sunset angle on the horizontal axis and the solar height angle on the vertical axis. The hours of the day are defined on each solar path.

Information is also provided on the temperatures at each solar hour and month, with its belonging or not to the comfort range.

Blue < 20ºC

Orange 20-27 ºC

Red > 27ºC

With this information, plus that of the psychometric abacuses, it is possible to study the solar trajectories to be protected in order to avoid overheating in the façade openings.

Note on interpretation between winter and summer months: Although both 6-month periods are symmetrical in terms of solar incidence, they are not symmetrical in terms of temperatures due to atmospheric and terrain thermal inertias. Differences are observed in the color points between the two graphs, for the two different periods, from June to December (higher temperatures) than from December to June.

Calculation of solar protection:

The angle of incidence to be protected is used. In the case of Oporto, protection elements can be provided to prevent solar entry at an angle of 55º from the horizontal. In this way, the entry of radiation in the hottest months of the summer, between June and September, is avoided. However, in order to capture radiation in the winter months, from June to December, the overhang should be shallower. An angle of 70º has been taken as a reference.

These angles are counted at 12 noon solar time. Proposed

protective element:

A horizontal solar protection is proposed above the openings that is capable of permanently protecting 70 degrees of solar incidence. And a part with protection flexibility (for example, the use of deciduous plants, or a mobile platform) that is able to protect an angle of 55 as a more restrictive measure for the hot months, from June to September.

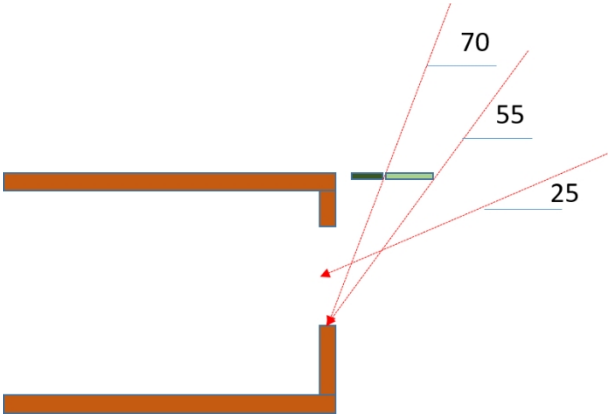


Figure 4. Section of a façade opening with the angles of incidence for the protection calculation.

It must be taken into account that the final dimensioning of the protection must take into account the specific information of the openings in the façade and the separation of the protection element from the façade.

EAST AND WEST FACADE

For these orientations, solar shading does not work in the same way as for the south. Incident radiation in the early morning (east facing) and late afternoon (west facing) are more horizontal in their trajectory and the overhangs above the openings are usually not sufficient.

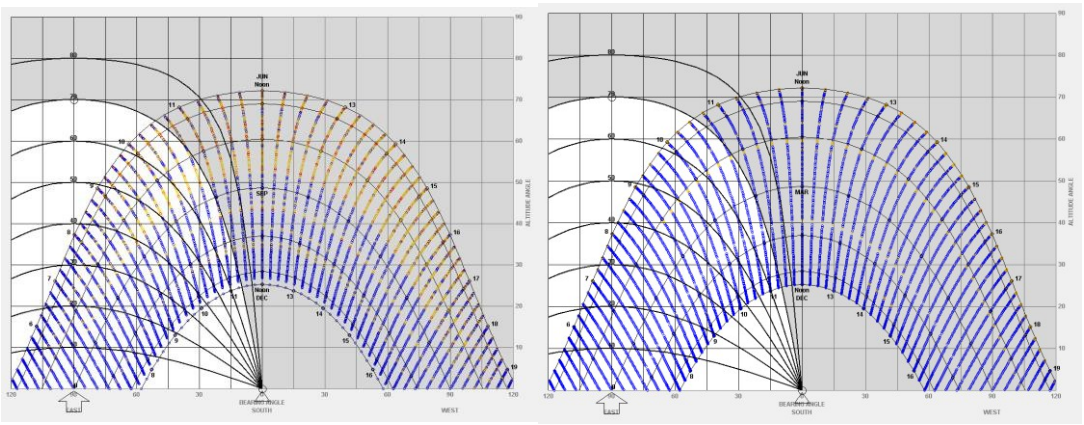


Figure 5. Cylindrical solar chart for the months of June to December (1) and December to June (2). With 70º angle sunshade overlay in east orientation.

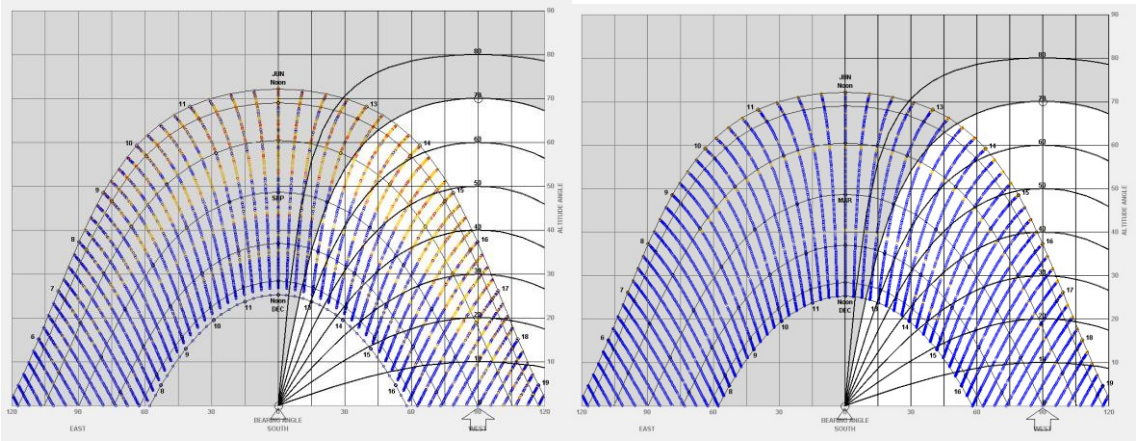


Figure 6. Cylindrical solar chart for the months of June to December (1) and December to June (2). With 70º angle sunshade overlay in west orientation

In this case, solar protection masks have been installed for 70-degree incidence, which is practically the maximum solar height for this location.

As can be seen, solar incidence cannot be stopped with horizontal overhangs above the openings, and other types of elements such as vertical louvers capable of obstructing the sun's path must be considered. This is especially relevant for facades facing west, with higher temperatures than those facing east.

2.2. Évora and Badajoz

The calculations for both locations have been combined because they are very close in latitude and have similar climates.

According to the psychometric abacuses, it would be necessary to incorporate sun protection strategies approximately from the end of May to the end of September. For the estimation of solar height and azimuth angles, the first day of protection was taken as May 30 and the last day as September 21 (Figure 7).

The months of May and October have more hours below comfort temperature than above. During June, July, August and September the heat predominates.

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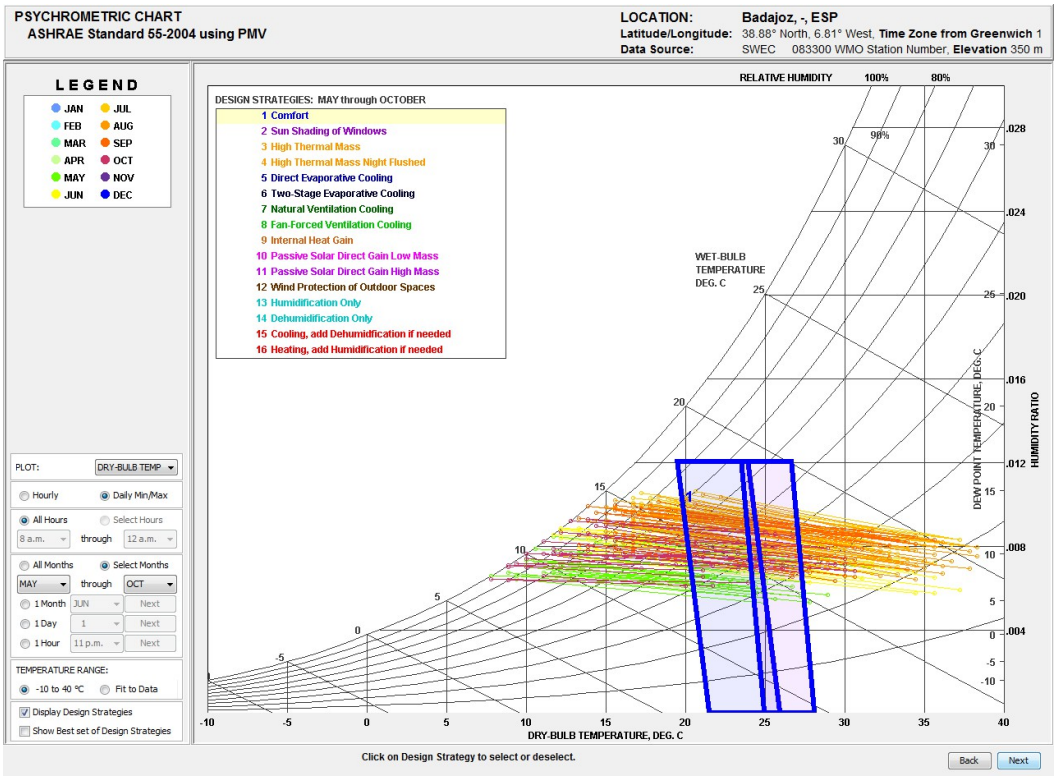


Figure 7. Representation of temperature evolution (line from minimum to maximum) from May to October. Climate of Évora and Badajoz.

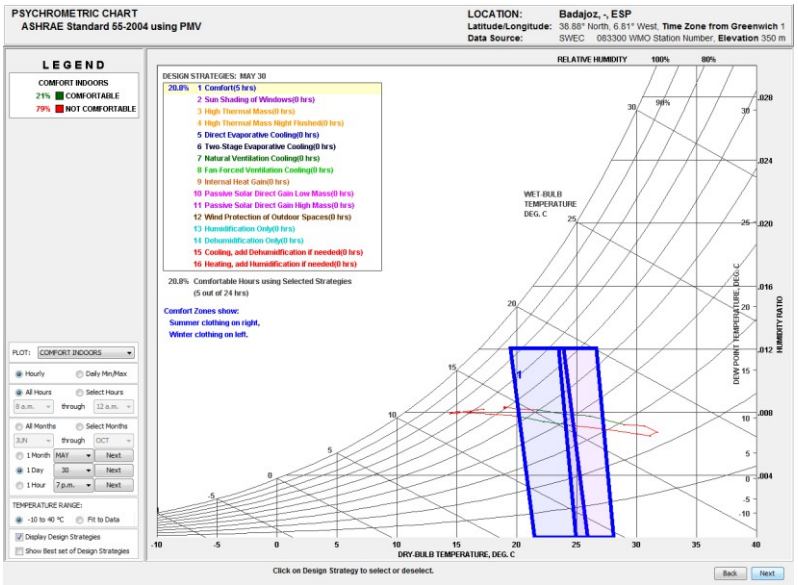


Figure 8. Hourly time course of temperature and humidity conditions for May 30.

As can be seen in Figure 8, from 1:00 p.m. onwards, temperature and humidity conditions are out of the comfort zone for the summer season.

"PROTOTYPE DESIGN. 03- Solar incidence and estimation of solar protection.

SOUTH FACADE

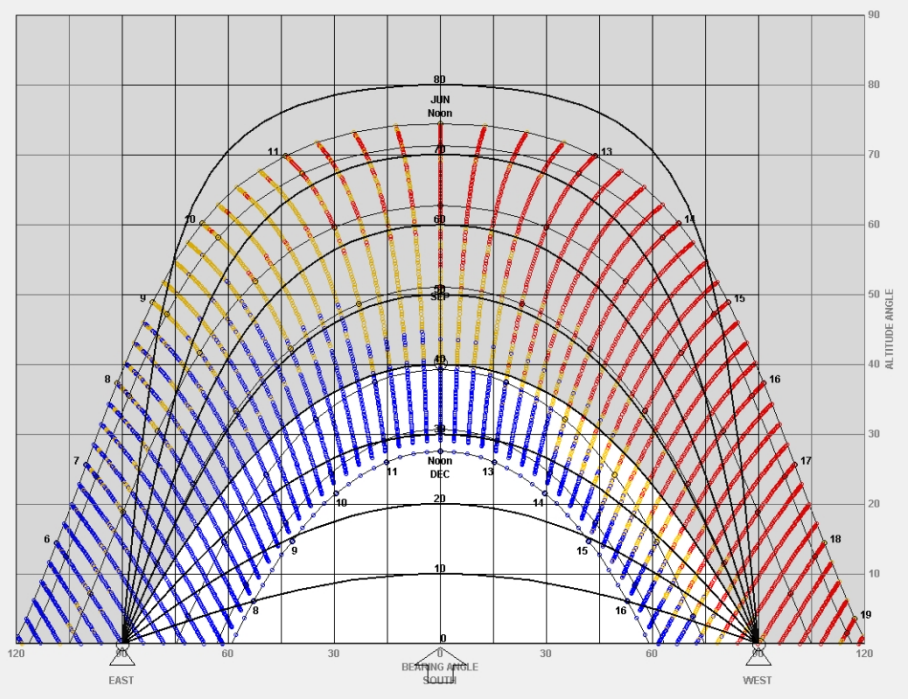


Figure 9. Cylindrical solar chart for Badajoz and Évora from June to December.

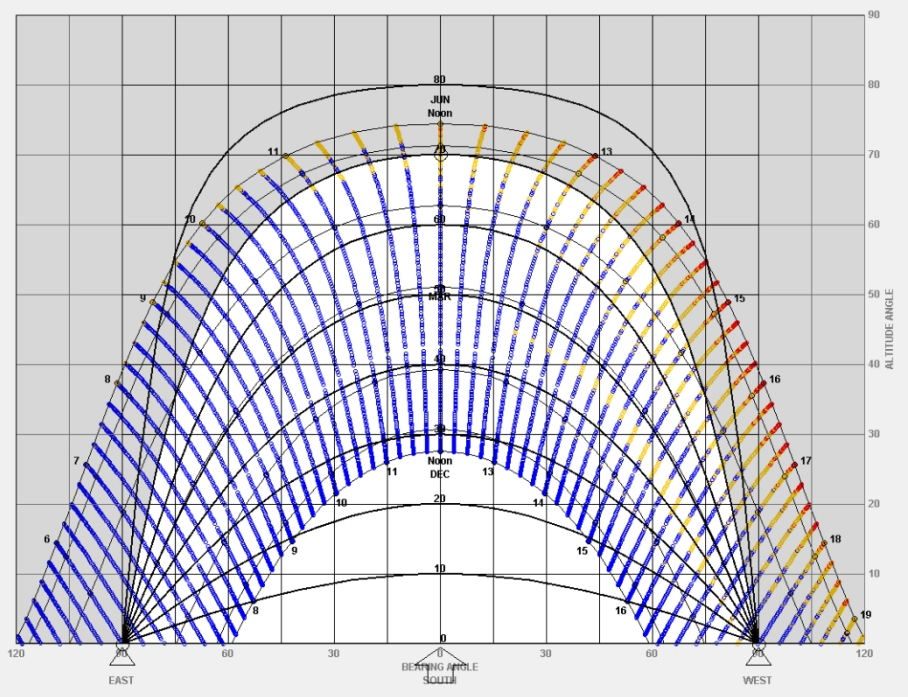


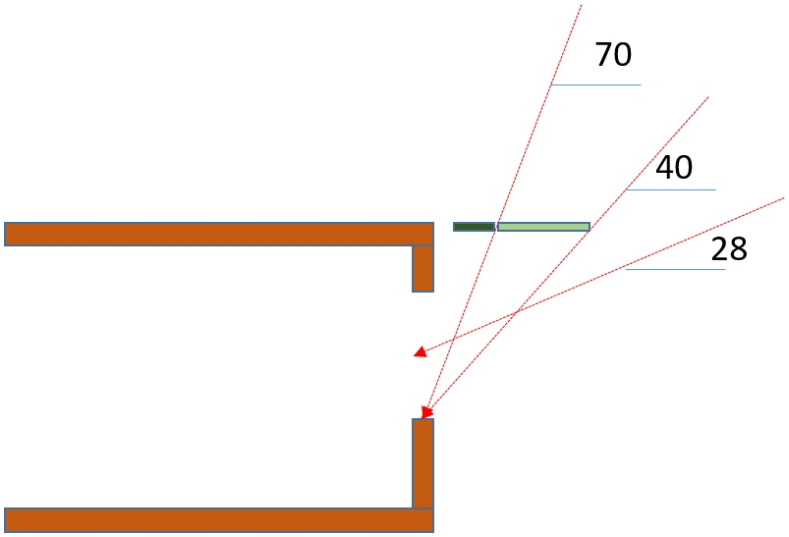
Figure 10. Cylindrical solar chart for Badajoz and Évora from December to June.

As was the case at the Porto location, the protection must be such that in the winter months it does not impair the entry of radiation in order to achieve passive solar gain.

In the same way, a cantilever is proposed to allow a double protection of angles. The first with a 70º protection from the sill that would block solar incidence from approximately May 30 to July 30. On the other hand, a flexible part that allows blocking the months of August and September (40º) but that can disappear from that month to allow the entry of radiation.

Proposal:

Protection option of 70º fixed, and 40º for moving part (or deciduous leaf).



Section of a façade opening with the angles of incidence for the calculation of protection. Badajoz and Évora.

EAST AND WEST FACADE

As in the case of Oporto, the east and west orientations do not work in the same way. The flatter solar incidence requires other types of elements.

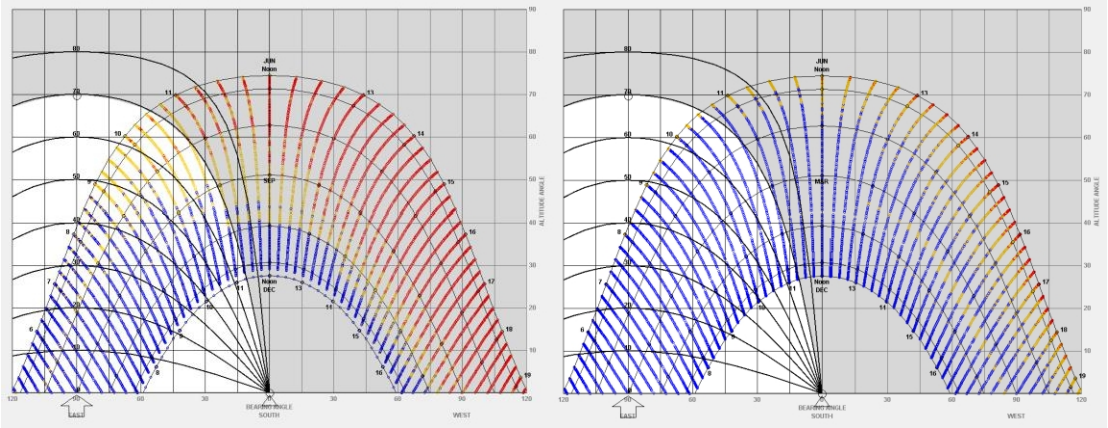


Figure 12. Cylindrical solar chart for the months of June to December (1) and December to June (2). With 70º angle sunshade overlay in east orientation.

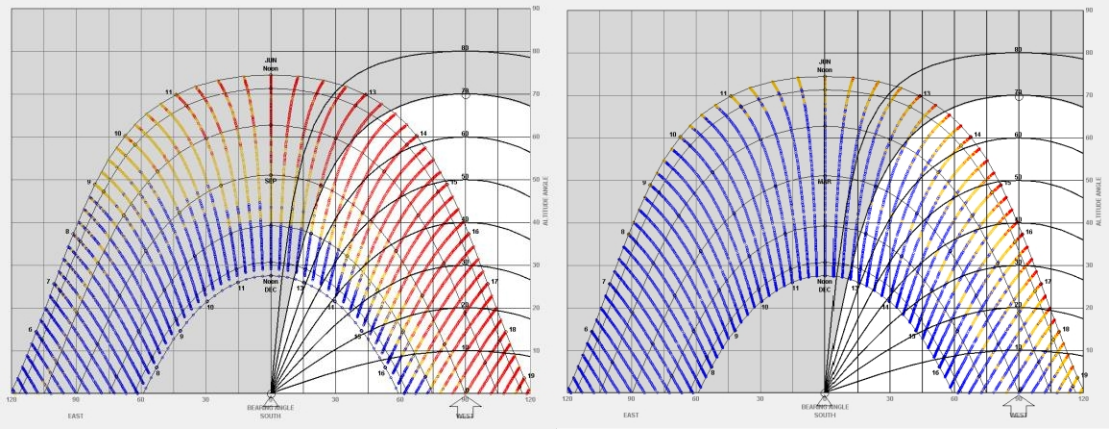


Figure 13. Cylindrical solar chart for the months of June to December (1) and December to June (2). With 70º angle sunshade overlay in west orientation.

As can be seen, solar incidence cannot be stopped with horizontal overhangs above the openings, and other types of elements such as vertical louvers capable of obstructing the sun's path must be considered.

Unlike the climate of Oporto, temperatures in Badajoz and Évora are much higher, and for the west orientation it is especially interesting to propose vertical protections that hinder radiation from angles of 70 degrees to 10 degrees.

3. CONCLUSIONS

The data obtained in this document constitute a climatic basis for decision making. Guidelines are given for achieving solar shading as one of the bioclimatic strategies with the greatest impact on the overheating of building interiors.

However, in order to be able to adjust the dimensions of the elements, more precise geometric calculations are needed to incorporate the specific openings, sill and lintel heights, wall thicknesses, existing overhang elements, and exact orientations of the facades.

On the other hand, the repercussions that these measures may have on the energy performance of the building can be analyzed with the simulation software. Once the prototypes have been incorporated, it will be possible to study the incidents in the hot months and also, and very importantly, the repercussions that these protections may have in the cold months. It is possible that as a result of these calculations it will be necessary to make some adjustments so that what is improved in summer does not harm the collection in winter as passive energy. This will be done with energy simulations for periods of a whole year.

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