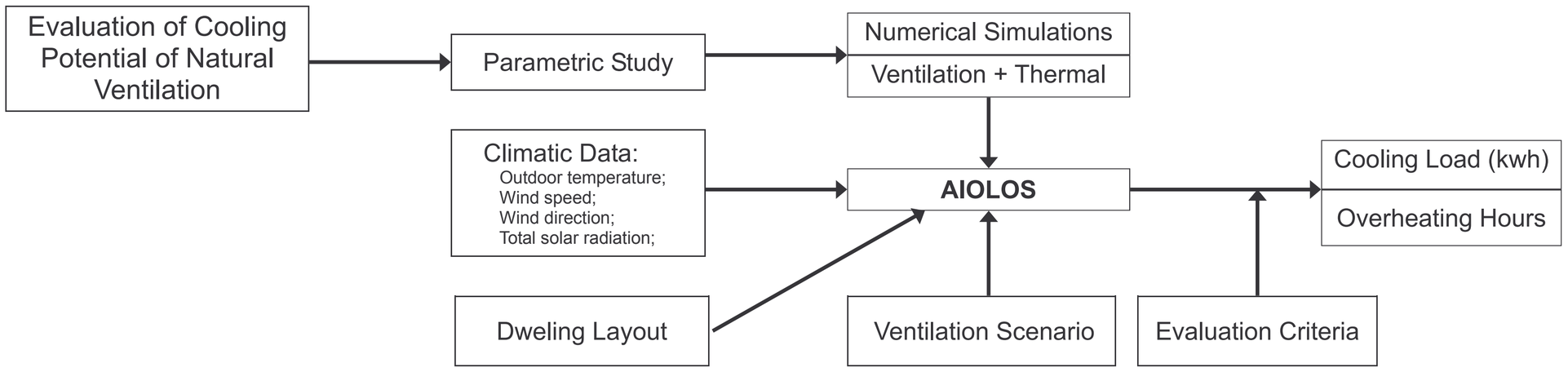
COOLING POTENTIAL OF NATURAL VENTILATION IN PORTUGUESE CLIMATIC CONDITIONS

Sara Verdelho; Helena Corvacho



AIOLOS

- Software for the calculation of air flow rates in natural ventilated buildings created in the scope of a European funded research project;
- Suitable for the calculation of global airflow rates in each simulated zone, calculation of airflow rates through each opening in the building;
- Allows users to perform sensitivity analysis for the investigation of the impact of specific parameters on natural ventilation and to perform optimization process for derivation of appropriate opening sizes;
- Includes a thermal model for assessment of the impact of various natural ventilation strategies on the thermal behaviour of the building; the link between the ventilation model and the thermal model is sequencial, first the program calculates airflows with a given indoor temperature which are provided to the thermal model that calculates the cooling loads and the number of overheating hours in relation to a specified comfort temperature.

EVALUATION CRITERIA

- Cooling potential of each scenario: reduction on the cooling load (kWh) and on the number of overheating hours obtained from different natural ventilation scenarios when compared to situation without ventilation;
- Natural ventilation can cause discomfort due to excessive air speed in the building;
- Allowable mean air speed inside a building is defined in ASHRAE Standard—113-1990 “Method of Testing for Room Air Diffusion”;

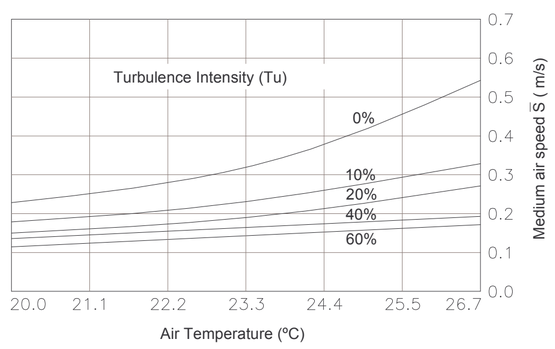


Figure 1 – Allowable mean air speed (m/s) inside of a building in function of indoor air temperature and turbulence intensity

- In the present study, the maximum value considered for the air speed in the middle of a room, defined for each hour, was of 0,5m/s.

CLIMATIC DATA

- Portuguese territory is divided into three summer climatic regions: V1(mildest), V2 e V3 (warmest);
- Simulations were performed in three different locations belonging to these three regions:

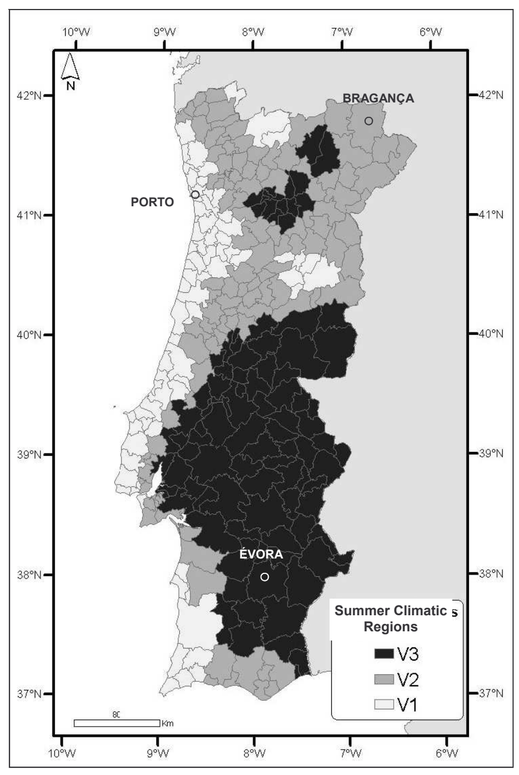


Figure 2 – Summer Climatic Regions in which Portuguese territory is divided and locations studied

Location	Climatic Region	Mean Outdoor Temperature for Jun, Jul, Aug and Sep. (ºC)	Design Outdoor Temperature* (ºC)	Mean Daily Temperature Amplitude for the Warmer Month (ºC)
Porto	V1	19	30	9
Bragança	V2	19	33	15
Évora	V3	23	35	17

* The Design Outdoor Temperature is the value of the outdoor temperature that for a given period of time (in this case for June, July, August and September) is exceeded only in 2.5% of the time.

DWELLING LAYOUT

FIRST GROUP OF SIMULATONS

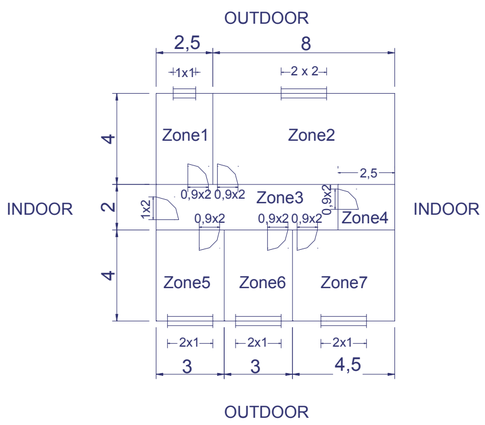


Figure 3 – Schematic plan of the standard dwelling used in the first group of simulations

SECOND GROUP OF SIMULATONS

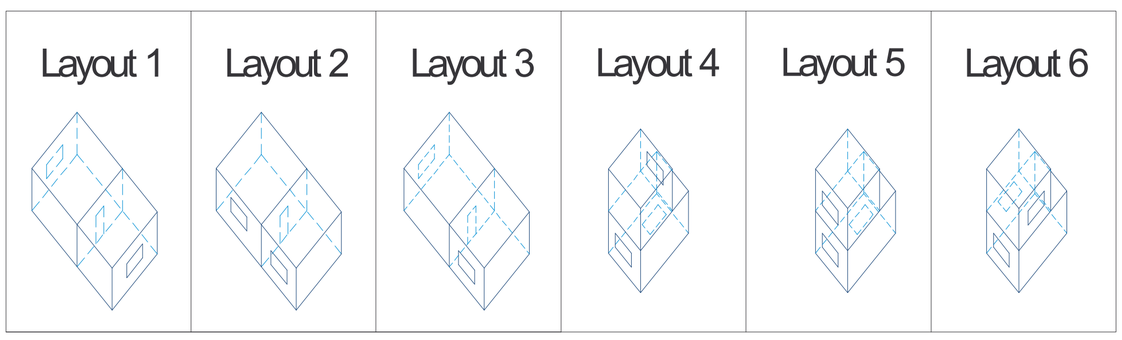


Figure 4 – Dwelling configurations considered in the second group of simulations with different opening locations in the facades.

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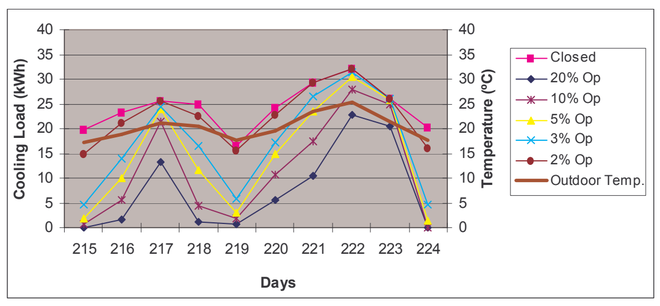
RESULTS

FIRST GROUP OF SIMULATONS — The Influence of The Size of Openings and Their Opening Schedule

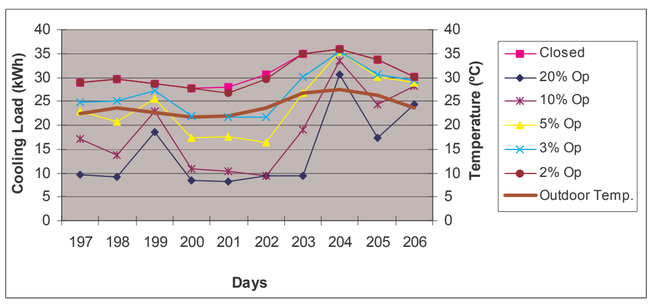
Simulations for the following working scenarios:

- All the windows closed;
- Open area of 20%, 10%, 5%, 3% or 2% of the windows area, whenever the outdoor temperature (T_{out}) is not above 25ºC;

PORTO



BRAGANÇA



ÉVORA

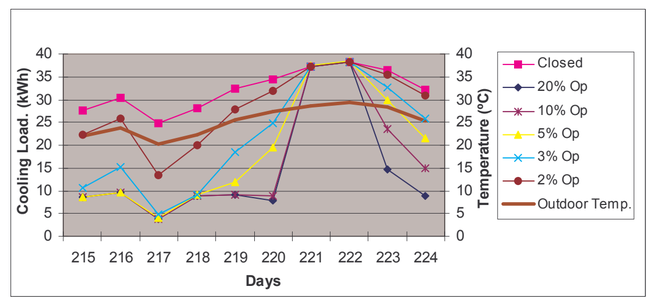
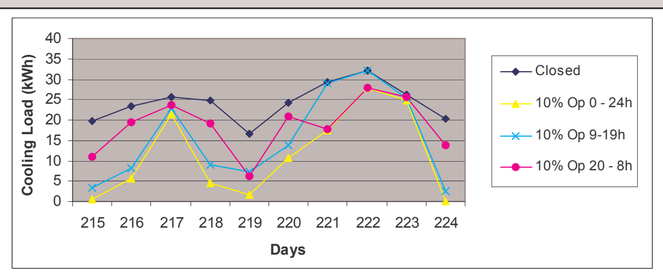


Figure 4 – Cooling Load (kWh) and Daily Mean Outdoor Temperature (ºC) for each location.

Simulations for the following working scenarios:

- All the windows closed;
- Open area of 10% whenever the outdoor temperature (T_{out}) is not above 25ºC for different ventilation schedules;

PORTO



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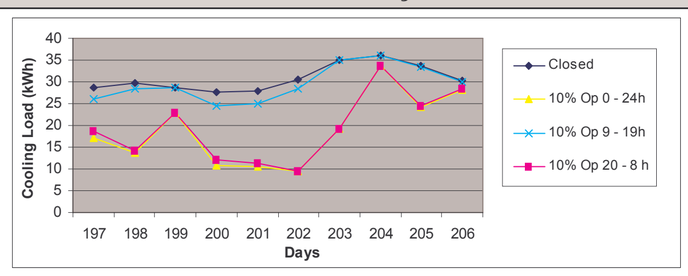


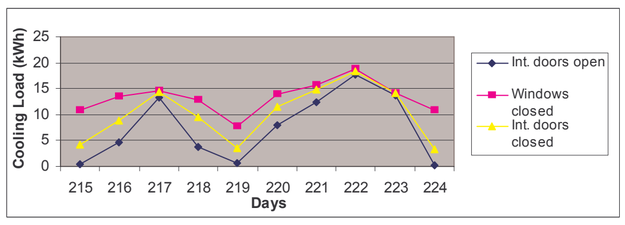
Figure 5 – Cooling Load (kWh) for Porto and Bragança, for different ventilation schedules.

SECOND GROUP OF SIMULATONS — The Influence of Openings Location and Dwelling Configuration

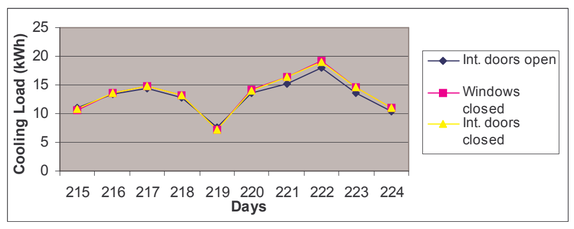
Simulations for the following working scenarios:

- For the location Porto, Layouts 1, 2 and 3, shown in figure 4, were studied considering windows closed or 10% open when Tout ≤ 25º C with interior doors open or closed;
- Layouts shown in figure 4 were calculated considering an open area of 10% of the windows area whenever T_{out} is not above 25ºC for locations Porto and Bragança;

LAYOUT 1



LAYOUT 2



LAYOUT 3

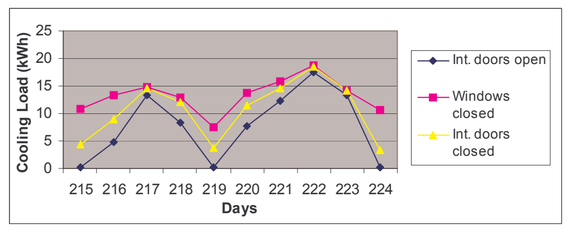
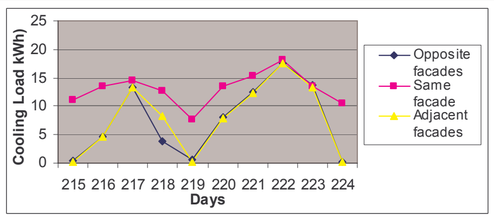


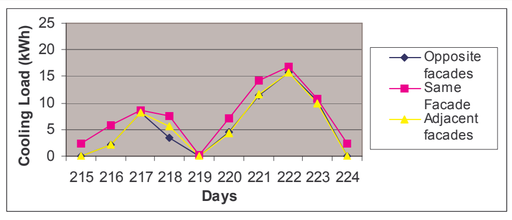
Figure 6 – Cooling load in Porto (layouts 1, 2 and 3) – comparison between all windows closed or windows 10% open (when T_{out}≤25ºC) and interior doors open or closed.

PORTO

LAYOUTS 1, 2 AND 3

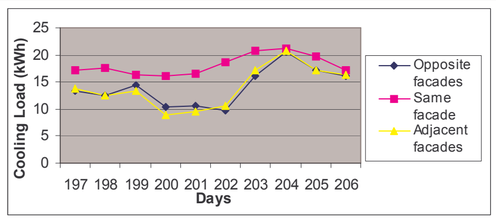


LAYOUT 4, 5 AND 6



BRAGANÇA

LAYOUTS 1, 2 AND 3



LAYOUTS 4, 5 AND 6

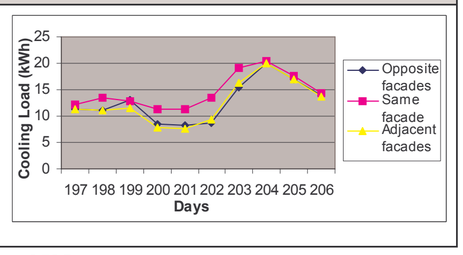


Figure 7 – Cooling load (kWh) in Porto and Bragança, for layouts 1 to 6 and open area of 10% of windows surface whenever T_{out} ≤ 25ºC.

CONCLUSIONS

- The results obtained in the first group of simulations present the following percentual reduction of the Cooling Load, for each percentage of opening of the window area:

Opening percentage	Porto	Bragança	Évora
20	67	45	57
10	57	39	53
5	44	22	45
3	34	13	36
2	8	1	14

- The adoption of natural ventilation strategies can have an important role in controlling energy consumption for cooling purposes. A well-designed natural ventilation system with an appropriate use can, considerably reduce the need of air-conditioning devices.
- When cross-ventilation is not possible, the designer should study the adoption of two storey typologies. If even this is not an option, then more than one opening should be planned for each indoor space and specific exterior devices to promote air inlet should be installed.
- The choice of the type of window frame is a determining issue, being the ones that allow several kinds of opening more efficient in what concerns the promotion and management of natural ventilation.
- Natural ventilation can possibly be sufficient, in summer conditions, if and only if some important aspects are also well controlled, the most important of which is the solar gain, this makes the use of efficient shading devices essential.