Improvement of classroom conditions and CO₂ concentrations through natural ventilation measures reinforced with NBS implementation

J. Fermoso (1), T. Torres (1), M.A. Antón (2), A. Peña (2), J. Muñoz (3), S. Torre (3), T. Batista (4), R. de Barros (4), B. Frutos (5), G. Gómez (5)

1. CARTIF Technology Centre. Spain
2. Sustainable Development Department-Diputación de Badajoz. Spain
3. Royal Botanical Garden (CSIC). Spain
4. CIMAC – Comunidade Intermunicipal de Alentejo Central. Portugal
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LIFE myBUILDINGisGREEN

Innovative NBS for adapting existing schools and educational buildings to climate change:

- Green roofs
- Green shadow structures for walls
- Creation of natural ventilation measures
- Green pavements
- Criteria for the selection of the vegetation

Designed by M.A. Antón.

What's Really Warming the World?

Bloomberg Businessweek

What's Really Warming the world? By Eric Roston and Blacki Migliozi (2015). Source: NASA, IPCC.

<https://www.bloomberg.com/graphics/2015-whats-warming-the-world/>

Is the Sun causing global warming?

Warming Stripes for GLOBE from 1850-2018 #ShowYourStripes

Graphics and lead scientist: [Ed Hawkins](#), National Centre for Atmospheric Science, University of Reading.
Data: Berkeley Earth, NOAA, UK Met Office, MeteoSwiss, DWD.
<https://showyourstripes.info/>

1. Building Energy Simulation
2. Classrooms monitoring (CO₂, Temperature and Relative Humidity)
3. Natural ventilation modelization
4. Temperature reduction by nature

1. Building Energy Simulation

Modelling for **CEIP Gabrila Mistral School** in Solana de los Barros (Spain) $38^{\circ}43'N$ $6^{\circ}32'O$

1. Building Energy Simulation

Modelling for **CEIP Gabriela Mistral School** in Solana de los Barros (Spain) 38°43'N 6°32'O

- Template used: Teaching areas which include classrooms and corridors providing access to and between classrooms.
- Analysis of the global energetic characteristics for the area for the whole year, summer time, weekly and daily (hot representative ones).
- Analysis of the implementation of passive measures:
 - Green roof
 - Shading of the openings
 - Night ventilation cooling
 - Greening the surroundings

School volumetric model for DesignBuilder® analysis.

Model Studies carried out by

1. Building Energy Simulation

Psychrometric diagram including optimal passive improvement measures during summer for **CEIP Gabrila Mistral School** in Solana de los Barros (Spain) 38°43'N 6°32'O

Model Studies carried out by

2. Classrooms monitoring

Indoor CO₂ and temperature monitoring in classrooms

Current practices Vs. parameters profiles (one example week)

Maximum Comfort Temperature
27°C

3. Natural Ventilation Modelization

Model parameters

OPTIVENT 2.1. A Natural Ventilation Steady-State Calculation Tool for the Early Design Stage of Buildings.

- Buoyancy and Buoyancy and wind driven ventilation studies.
- Both required and achieved
- Temperature range of the study 25 - 32°C.
- Effective apertures 15 – 85%
- Standard heat internal gains
- 30 people
- Classroom 10x8x3 m
- Openings surface 2m²
- Standard Wind 3m/s
- Standard indoor temperature 32°C

Example of OPTIVENT 2.1 parameters screen.

<http://naturalcooling.co.uk/OV21/optivent/optivent.php>

3. Natural Ventilation Modelization

Ventilation (requirements $0,3\text{m}^3/\text{s}$)

It is only shown Buoyancy drive ventilation results. Buoyancy and wind drive mode gets targets values easily.

Difference required airflow for ventilation and achieved airflow with different effective apertures at different outdoor temperatures

3. Natural Ventilation Modelization

Ventilation and cooling (requirements depending on the outdoor temperature)

It is only shown Buoyancy and wind drive ventilation results. Buoyancy drive mode does not get targets values.

Difference required airflow for cooling and achieved airflow with different effective apertures at different outdoor temperatures

4. How to reduce outdoor temperature

Nature-Based Solutions for building surrounding temperature reduction

- Green Screens acting as natural shades combined with programmed irrigation.

<http://organicdesign.co.jp/>

Private house.
Designed by Hideo Kumaki Architect Office.

© Saverio Lombardi Vallauri

USA Pavilion Expo Milano 2015.
Designed by Biber Architects.

4. How to reduce outdoor temperature

Nature-Based Solutions for building surrounding temperature reduction

- Green Screens acting as natural shades combined with programmed irrigation.

Green Canopy Prototype.

Designed by Singular Green (<https://www.singulargreen.com>) and CARTIF.

4. How to reduce outdoor temperature

Initial reduction studies through NBS

Simple Experimental setup

- 3L chamber
- Temperature and humidity monitoring of the indoor and outdoor air
- Flow rate control of inlet air
- Isotherm hot room
- Same initial water amount for irrigation
- Similar vegetal weight

4. How to reduce outdoor temperature

Temperature and relative humidity profiles

MOSS EXPERIMENT – Mos10

- Moss – *Syntrichia Ruralis*
- 10Lmin^{-1} Air flow rate
- Vegetal mass 22g
- Initial Irrigation water 40g

Results

- Average temperature difference while material is wet
3,8 °C
- Maximum temperature difference
4,2 °C

4. How to reduce outdoor temperature

Temperatures Difference

This study aimed to assess natural ventilation and Nature-Based Solutions implementation for adapting vulnerable building to climate change in South Europe.

- Abundant research indicate that Natural ventilation measures can **improve indoor environments, reduce temperature and CO₂ concentration** and be cost effective in combination with NBS implementation.
- **Our Modelling studies** show that, by implementing passive measures, it is possible to get almost 100% of **thermal comfort** time in vulnerable buildings.
- **User awareness** is also necessary to implement **Natural ventilation formulas**.
- Through the combination of passive measures with **Nature-Based Solutions**, ventilation and thermal comfort in hot season can be more easily achieved.
- Our study helps to better meet the challenge of **adapting vulnerable buildings to climate change** following the criteria of carbon neutral solutions.

Acknowledgements

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My school is green!
¡Mi cole es verde!
Minha escola é verde!

Contact

- Salustiano Torre. Real Jardín Botánico (CSIC)
- @lifemybuildingisgreen
- #lifemybuildingisgreen

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Thank you!

Jose Fermoso
josdom@cartif.es

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DE BADAJOZ

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