A ventilative cooling system in a School Building, Imola, Italy

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Two main blocks linked by a central atrium
East-West longitudinal axis

library, cafeteria, offices and laboratories
entrance
central atrium
classrooms

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PRELIMINARY - PHASE 1

- Focussed simulations of energy strategies and comparison to a benchmark configuration
- Calculation of annual energy needs using simplified tools

**Estimate of energy needs**

**PRELIMINARY - PHASE 2**

- Evaluation of energ-saving benefit related to alternative strategies

**SOLUTION D**

to optimise yearly energy balance

**TECHNOLOGICAL OPTIONS FOR INDOOR CLIMATE CONTROL SYSTEMS**
Ventilation system

Hybrid system (controlled natural/mechanical system)

Controlled natural ventilation (CNV): motorised sensor-driven openings related to IAQ and thermal comfort

Cafeteria and discontinuous-use spaces:
- Winter - mechanical
- Summer – mechanical

Atrium:
- Winter - mechanical
- Summer – mech. + CNV

Classrooms:
- Winter - mechanical
- Summer – mech. (during occupation) + CNV

Cooling system

Night cooling of thermal mass (NCTM)

Radiant floor

Mechanical ventilation

Vacuum Solar Collectors on roof

Air-to-Earth Heat Exchangers

AHU

Absorption chiller

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Night cooling of thermal mass

Natural stack-driven airflow through a class room and the atrium

TORRINO DI ESTRAZIONE: ribalta aperta $S_{ap} = 33 \, m^2$

Natural stack-driven airflow through a class room and the atrium

AULA PIANO SECONDO ribalta aperta $A_{ap} = 1 \, m^2$ per std

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Night cooling of thermal mass

2D CFD simulation: temperature zones for a gradient of 10 °C between inside and outside

![Diagram showing temperature zones after 1 minute, 10 minutes, and 1 hour.](image)

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Night cooling of thermal mass

3D CFD simulation: temperature zones for a gradient of 10 °C between inside and outside

![Diagram showing temperature zones after 5 minutes, 35 minutes, and 1 hour.](image)

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Night cooling of thermal mass

CFD airflow simulation: global thermal exchange between air and surfaces

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Hourly air temperature annual profile: ambient (blue); indoor in South classrooms, without (pink) and with (green) NCTM.
### Contribution to energy saving of RES & RUE technologies (prediction)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Annual energy intensity [kWh/m²-gfa]</th>
<th>Heating</th>
<th>Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference configuration (a)</td>
<td></td>
<td>79.5</td>
<td>22.4</td>
</tr>
<tr>
<td>Reference configuration (b)</td>
<td></td>
<td>141.0</td>
<td>38.3</td>
</tr>
<tr>
<td>High insulation (opaque components)</td>
<td></td>
<td>72.7</td>
<td>25.1</td>
</tr>
<tr>
<td>High insulation (glazed components)</td>
<td></td>
<td>66.2</td>
<td>28.6</td>
</tr>
<tr>
<td>Time optimisation of mechanical ventilation (OMV)</td>
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<td>64.9</td>
<td>15.4</td>
</tr>
<tr>
<td>Shading devices (fixed)</td>
<td></td>
<td>84.0</td>
<td>15.8</td>
</tr>
<tr>
<td>Shading devices (fixed and movable)</td>
<td></td>
<td>88.8</td>
<td>14.0</td>
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<tr>
<td>Total of envelope technologies (ET)</td>
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<td>67.0</td>
<td>20.1</td>
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<tr>
<td>ET + OVM + heat recovery</td>
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<td>44.3</td>
<td>13.4</td>
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<tr>
<td>ET + OVM + Solarwall®</td>
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<td>42.5</td>
<td>13.4</td>
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<tr>
<td>ET + OVM + NCTM</td>
<td></td>
<td>54.1</td>
<td>6.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>37.4</td>
<td>6.6</td>
</tr>
</tbody>
</table>

### Annual energy intensity and U-values:
- **U-value (walls)** = 0.45 W/m²K
- **U-value (glazing)** = 2.65 W/m²K
- **Mech. Vent. for 12 h/day**
- **As configuration (a) with Mech. Vent. for 24 h/day**
- **U-value (walls)** = 0.30 W/m²K
- **U-value (glazing)** = 1.57 W/m²K

**179500 kWh/year**

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