Vertical Greenery Systems (VGS) for energy savings in buildings

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• Vertical Greenery Systems contribute positively to the improvement of the built environment:
  – Aesthetics – urban landscaping
  – Support to biodiversity
  – Noise reduction
  – Energy savings – Heat island reduction
  – Etc.

Introduction

Thuir, France

Pergola Building
Belén, Costa Rica
Introduction

- The classification of VGS must be taken into account for energy savings purposes

<table>
<thead>
<tr>
<th>Green façades</th>
<th>Extensive systems</th>
<th>Intensive systems</th>
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<tbody>
<tr>
<td></td>
<td>Traditional</td>
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<tr>
<td></td>
<td>Double-skin</td>
<td>Modular trellis</td>
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<td></td>
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<td>Wired</td>
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<td></td>
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<td>Mesh</td>
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<td>Living walls</td>
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<td>Perimeter flowerpots</td>
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<td>Panels</td>
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<td>Geotextile felt</td>
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</table>

• The main mechanisms of VGS as passive tool for energy savings are four:
  – **Shade effect**: Interception of the solar radiation by the plants
  – **Cooling effect**: Due to the transpiration from the plants
  – **Insulation effect**: Air layer create in the foliage
  – **Wind barrier effect**: Variation of the direct wind effect over the building façade by the plants and the support structure

• **Shade effect** seems to be the most influential
Introduction

• Difficulties to measure the influence of VGS on building thermal performance:
  – Differences between constructive systems
  – Living organisms (species, growth, diseases, etc)
  – Different climate conditions
  – Difficulties to quantify the effects individually
Objectives

• To study the use of VGS as passive tool for energy savings in Mediterranean continental climate
  – To quantify the shadow effect
  – To quantify the energy savings

• These studies are conducted in a large real scale installation that the research group  GREA has in Puigverd de Lleida (Lleida, Spain). [http://www.grea.udl.cat](http://www.grea.udl.cat)
Previous research

- Previous actions
  - Action 1: Shadow capacity of different climber species. 2009-2010
  - Action 2: Thermal behavior of green facades in an existing experimental cubicle. 2010-2011


Previous research

- Action 1: Shadow capacity of different climber species. 2009-2010
  - The ability to intercept solar radiation of vegetation, even at low foliage densities, is similar to that offered by artificial barriers such as awnings, slats, etc. according to the Spanish technical code for buildings (CTE).

<table>
<thead>
<tr>
<th>Artificial barrier</th>
<th>shadow factor</th>
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<tbody>
<tr>
<td>Cantilever</td>
<td>0.16 – 0.82</td>
</tr>
<tr>
<td>Setback</td>
<td>0.17 – 0.82</td>
</tr>
<tr>
<td>Opaque awnings</td>
<td>0.02 – 0.43</td>
</tr>
<tr>
<td>Translucent awnings</td>
<td>0.22 – 0.63</td>
</tr>
<tr>
<td>Horizontal slats</td>
<td>0.26 – 0.49</td>
</tr>
<tr>
<td>Vertical slats</td>
<td>0.32 – 0.44</td>
</tr>
</tbody>
</table>

![Graph showing transmissivity of light over different times of the day for different climbers.](image-url)
Previous research

- Action 2: Thermal behaviour of green facades in an existing cubicle. 2010-2011
Previous research

- Action 2: Thermal behaviour of green facades in an existing cubicle. 2010-2011
  - The shadow effect is evident over the wall surface temperature, reaching 14 °C less than in the reference cubicle with 50% of the surface covered.

![Shade capacity (14 °C)](image)
Previous research

• Action 2: Thermal behaviour of green facades in an existing cubicle. 2010-2011
  – Shadow effect influences over indoor temperature too. The reduction was about 1 °C less in the facade cubicle under free floating conditions.
Previous research

- **Action 2: Thermal behaviour of green facades in an existing cubicle. 2010-2011**
  - Some energy savings was observed for the accumulated energy consumption under indoor controlled conditions (24 °C)

Accumulated energy consumption by the heat pumps.
July 2011. Set-point 24 °C
Current research

- As the previous results were positive, a new green facade have been built, covering the east, south and west walls
Current research

- Deciduous vegetation (Boston Ivy, *Parthenocissus Tricuspidata*) was planted in June 2012 and was growing during summer 2012 and spring 2013.
Current research

- Data from summer 2013 show the shade effect, with a set point of 24 ºC
Current research

- And interesting energy savings (set point 24 °C), up to 50%
Current research

- In 2014 a Green Wall was built (BuresInnova S.A.) on another identical cubicle
  - Well adapted perennial bushes *Helichrysum stoechas* and *Rosmarinus officinalis*
Current research

- Data from summer 2014 with a set point of 24 °C. The shade effect was confirmed for the Green Wall too.
Current research

- Data from summer 2014. Energy savings of more than 50%
Further research

• In 2013 a review of the scientific literature available to date regarding to the use of VGS as passive tool for energy savings was conducted


• Some of the most important conclusions which will guide future research are:
  – The number of species used for Green Facades is very limited, mostly climbing plants, having two predominant species:
    • Ivy (*Hereda helix*) ➔ *Perennial*
    • Boston Ivy (*Parthenocissus tricuspidata*) ➔ *Deciduous*
    • Chinese Wisteria (*Wisteria sinensis*) ➔ *Deciduous*
  – For Green Walls the number of species used is higher, mostly herbaceous and bushes, but this can result in different thermal behaviours in the same Green Wall
Further research

- Most of the studies found are located in Europe (mainly Green Façades) and Asia (mainly Green Walls).
Further research

- A lack of studies in areas of the world that receive more radiation, in which these systems consequently could be more effective, have been observed.
Further research

- The most interesting parameters to consider for energy savings purpose design of VGS are:

<table>
<thead>
<tr>
<th>Purpose/period Heating/Cooling/Both</th>
<th>Traditional Green Facades</th>
<th>Double-skin Green Facades</th>
<th>Green Walls</th>
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</thead>
<tbody>
<tr>
<td>Species used</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Facade orientation</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Foliage thickness (or coverage %)</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Air gap thickness</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Substrate thickness and composition</td>
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<td>x</td>
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</table>
Conclusions

• Shade effect
  – Vertical Greenery Systems (VGS) show a great shade effect with reductions in outside wall surface temperatures ranging from 7 °C to 12 °C, for Green Facades, and up to 17 °C for Green Walls, for the studied constructive systems

• Energy savings
  – This shade effect implies great energy savings around 50 %, in summer periods, for the studied constructive system, under Mediterranean Continental climate
Conclusions

• Further research
  – To study the contribution of the different effects on energy savings
  – To study the suitable plant species for energy savings purpose
  – To develop these systems in areas of the world that receive more radiation
  – To focus the research/design on the parameters/variables that regulate the thermal behavior of these systems:
    • Purpose/period (heating/cooling) – Species – Orientation – Foliage thickness - Air gap – Substrate thickness and composition
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• To all co-authors of this work
Thank you for your attention

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