Green walls: Thermal and Hydrological Costs and Benefits

E-Futures Mini Project 2
Summary Report
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Introduction

The massive increase in urbanisation throughout the 20th and 21st centuries, has lead to increasing focus on the greening of urban space as a form of sustainable technology to mitigate ecological and climate change in the built environment [1].

Green walls and facades are seen as one solution, along with green roofs, and it is suggested that there is approximately double the area available in urban areas for green walls [2].

Project Aims

In this report we summarise the key points from current understanding of green walls, and report findings from some simple modelling of the thermal and hydrological costs and benefits.

Types of Green Wall

In the literature, green walls are generally referred two in three distinct categories:

Green Facades

These are systems of climbing plants, such as ivy, and are planted into the ground or planter boxes [2]. They may be supported by trellis or an engineered support, and can be naturally or artificially irrigated [3-4].

Figure 1 - Green facade in Berlin

Living Walls

These systems in which plants are grown vertically, commonly grown in a structure attached to the wall containing growth medium [3]. These are generally irrigated artificially.

Figure 2 - Mobilane LivePanel(tm) system in Birmingham

Biowalls

These are generally green walls in interior spaces, and may comprise of either facades or living wall systems [4-5]

Figure 3 - Biowall at Melvita, London

Methods

This project was carried out in three parts:

1. Literature review of existing case studies
2. Thermal modelling of a simple 1-storey home in two contrasting

climatic scenarios. This was carried out using DesignBuilder software [6].

3. Hydrological modelling of the same. This was carried out using EToCalc [7].

Results

Literature Review

Manufacturers claim that green walls "can provide environmental benefits in the form of biodiversity, thermal insulation and cooling benefit to the building, and noise attenuation, as well as water management and mental health benefits" [8]. However, little or no data is provided to back this up.

There are few experimental studies in the literature. These have carried out in warmer climates such as Hong Kong, Southern Europe and Tokyo. In general, a maximum internal cooling effect of 7^{o}C has been observed [9]. Typical cooling values are around 2-3^{o}C [10-11].

More theoretical studies have been carried out, and have looked at a wider variety of climatic scenarios. In hotter climates such as Riyadh and Mumbai, a potential 54-100% reduction in cooling demand has been calculated [12]. However, for cooler climates such as Sweden, green walls showed no effect for buildings insulated to good standards [13].

Thermal Modelling

A simple 1-storey home was used, the design of which had been used in a previous masters project at Sheffield University [14].

The effects of a green wall were modelled for insulated and uninsulated buildings in Nottingham and Dubai, in winter and summer (Nottingham was used as a close approximation for Sheffield). Results are summarised in the tables below

For the insulated building, only small temperature differences were calculated, with the maximum cooling/insulating effect of 1^{o}C or less. Larger effects were calculated for the uninsulated building, with a maximum cooling effect of 2.4^{o}C in the Dubai summer.

For the insulated building this equates to annual savings of:

- 544 kWh (6.5%) in Nottingham
- 811 kWh (4.6%) in Dubai

Nottingham	**No Green Wall / °C**	**Green Wall / °C**	**Difference / °C**	**Uninsulated - No Green Wall / °C**	**Uninsulated - Green Wall / °C**	**Difference / °C**
Winter						
Average	10.59	11.05	**0.46**	6.99	8.99	**2.00**
Max	17.22	17.03	**-0.19**	13.66	13.06	**-0.60**
Min	5.21	6.16	**0.95**	1.55	5.21	**3.66**
Summer						
Average	27.62	27.72	**0.11**	21.98	23.13	**1.15**
Max	37.65	37.02	**-0.63**	32.09	30.64	**-1.46**
Min	19.29	19.66	**0.37**	13.92	17.13	**3.22**
Dubai						
Winter						
Average	27.98	28.22	**0.24**	21.82	23.28	**1.47**
Max	35.67	35.34	**-0.34**	30.53	29.25	**-1.28**
Min	18.67	19.75	**1.07**	12.44	16.76	**4.32**
Summer						
Average	42.4	41.4	**-0.95**	36.7	36.2	**-0.53**
Max	48.8	49.5	**0.68**	44.2	41.9	**-2.36**
Min	32.5	32.1	**-0.41**	26.5	28.1	**1.60**

Table 1 – Summary of temperature data for Nottingham and Dubai

Hydrological Modelling

The potential water use for a green wall on the 1-storey home was calculated using weather data collected at Sheffield University [15]. Rainfall data was used to estimate potential rainwater harvesting from the roof of the house. The green wall has an area of 130 m^2, and a room area of 97 m^2. The graph below shows a comparison of the two data sets for Sheffield in 2008:

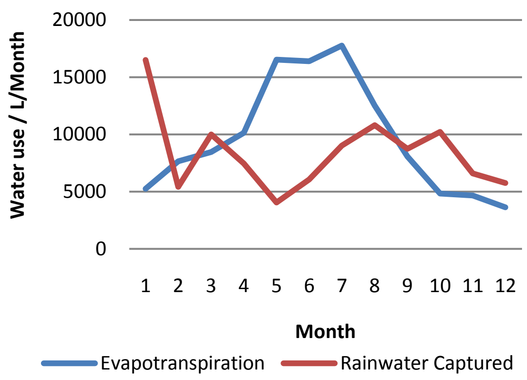

Figure 4 - Hydrological data for Sheffield, 2008

As can be seen, there is a significant disparity in the amount of rainwater harvested compared to water required. Energy costs to pump harvested rainwater and for purified mains water were estimated using figures from the South East Queensland Water Board, Australia [16], as no figures were readily available for the UK.

For Sheffield:

- 115,000 L required
- 100,000 L captured (160 kWh required)
- 15,000 L mains water (12 kWh required)
- Energy cost **172 kWh**

Figures for Dubai were estimated due to time constraints. Given that Dubai is hot and dry all year round, the maximum monthly evapotranspiration rate for Sheffield was used for each month in Dubai. It was also assumed that Dubai obtains most of its water from desalinisation. Annual rainfall data obtained from UAE Meteorological service [17].

For Dubai:

- 216,000 L required
- 58,600 L captured (87 kWh required)
- 157,400 L mains water (630 kWh required)
- Energy cost **717 kWh**

Conclusions

Overall energy savings:

- Sheffield/Nottingham: 372 kWh
- Dubai: 94 kWh

At an approximate price of 23p/kWh, this gives an annual saving of:

- Sheffield/Nottingham £87
- Dubai £22

Given that the typical installation costs for a living wall of this size is approximately £500/m^2, the payback period in terms of energy benefits alone would be prohibitive.

The overall thermal benefits to a well insulated building are small. Whilst there may be benefits to retrofitting on an uninsulated building, it may be economically more effective to update the building fabric.

In conclusion, it is though that prior to installing a green wall, a full assessment of the potential costs against the perceived benefits should be made, with an eye to the fact that energy benefits may be small.

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