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Living Walls – A Way to Green the Built Environment

Susan Loh

LIVING WALLS – A WAY TO GREEN THE BUILT ENVIRONMENT

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Green or living walls is an emerging technology that integrates vegetation into the built environment. This paper looks at the benefits that living walls can offer to our built environment and why this emerging technology should be considered as a valuable part of design for addressing climate change. It describes current methods of implementing living walls and points out some elements that should be considered for their successful implementation in Australia.

Note: There is a glossary at the end of this paper.

Keywords: *bio-walls, building façade, climate change, green façades, green walls, living walls, plants, Urban Heat Island (UHI), vertical vegetation*

1.0 INTRODUCTION

With the growing concern about climate change, there has been increasing interest in using living walls as part of a sustainable strategy for the urban environment. As this technology is still emerging, there is limited technical data available at present. This paper aims to show how living walls can contribute significant environmental, social and economic benefits to our built environment and highlights several elements that should be considered for their successful implementation in Australia.

The benefits of living walls such as the lowering of interior building temperatures (in warmer climates) and improved indoor air quality have been documented in several case studies overseas. As this body of knowledge grows, designers are gaining more evidence to convince them of the value of incorporating living walls into their buildings.

Living walls are sometimes called **green walls**, **green façades**, **bio walls** or **vertical vegetation.** The term refers to vegetation that grows directly onto a building's façade or to vegetation that is grown on a separate structural system that can be freestanding and adjacent or attached to the wall. Vegetation grown in planter boxes and trained on a freestanding or attached trellis system and with mechanised watering is also referred to as living walls. (Centre for Subtropical Design, 2007)

The Centre for Subtropical Design at Queensland University of Technology proposes that for future definition, **living walls** be defined as having multi-functional and deliberate environmental benefits for their built surroundings, and that living walls may be clearly identified as designed, built and maintained vegetation elements associated with a building (Centre for Subtropical Design 2007).

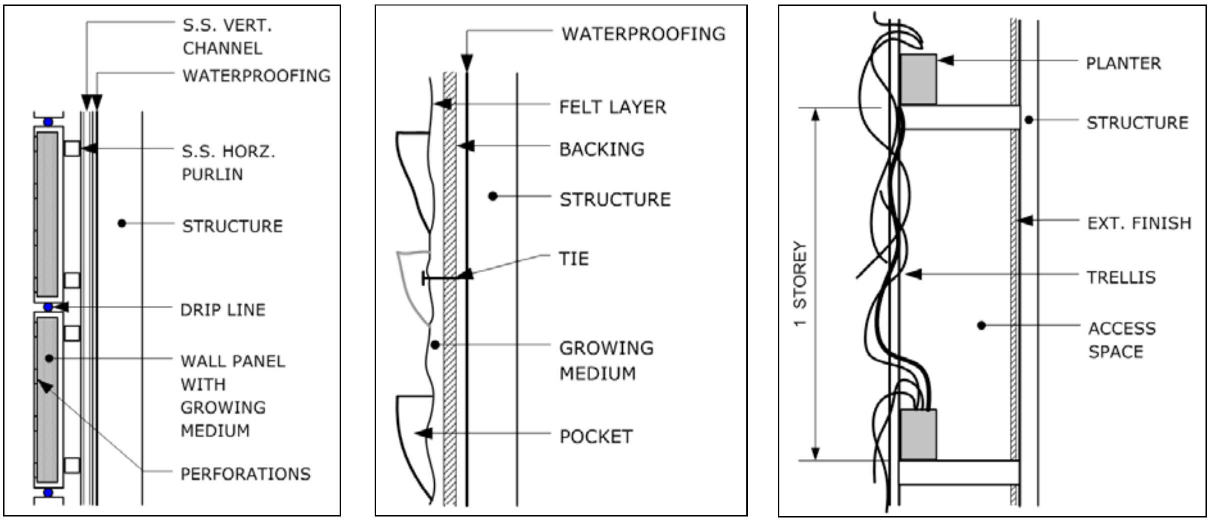
2.0 TYPES OF LIVING WALLS

Living walls can be internal or external to the building envelope and can be broadly classified into three systems:

- ***Panel System:*** which normally comprise of pre-planted panels that are brought on site and connected to the structural system and a mechanical watering system.
- ***Felt System:*** where plants are fitted into felt pockets of growing medium and attached to a waterproofed backing which is then connected to structure behind. The felt is kept continually moist with water that contains plant nutrients.

- ***Container and/or Trellis System:*** where plants grown in containers climb onto trellises. Irrigation drip-lines are usually used in the plant containers to control watering and feeding.

Interior Living Walls can be built out of any of the above three systems. Some of these walls are specifically integrated with the building's mechanical system. Recycled and fresh air can be supplied to the building's interior through the living wall and thus the air is cleansed and humidified by the plants and growing medium.



Panel System　　Felt System　　Container and/or Trellis System

Figure 1　The three generic green wall systems

Vertical cross-section through walls – not to scale.　(Source: Susan Loh. Drawing by M. Murray, 2008)

3.0 BENEFITS

Current research has shown that incorporating living walls into building design has several benefits:

1. lowering energy consumption and greenhouse gas emissions
2. reduction of Urban Heat Island effect (UHI)
3. increasing the thermal performance of buildings (lowering energy costs)
4. positive effects on hydrology and improving water sensitive urban design (WSUD)
5. improvement of Indoor Air Quality (IAQ)
6. reduction of noise pollution
7. increasing urban biodiversity and urban food production
8. improvement of health and well-being

3.1 Lowering of Energy Consumption through Increased Thermal Performance of Buildings

Studies have shown that a vine sunscreen such as ivy, growing directly on a west wall provides effective shading of the wall – thus contributing to lower heat absorption of the wall and therefore lower indoor temperatures (Hoyano, 1988, 188). For instance, a temperature difference of 10ºC was recorded between exposed wall surfaces with and without the plant screening in a study by Hoyano in Tokyo. Similarly, the cooling effect of greenery on a west wall in Beijing reduced the peak-cooling load transfer to the building's interior on a clear summer day by 28 per cent. (Di, 1999).

Computer simulation models conducted by researchers in a colder climate like Canada show that the shading provided by living walls lowers indoor temperatures significantly in summer and can translate to a lowering of energy costs by 23 per cent (Bass and Baskaran 2001, 85). In cooler climates, the use of deciduous species allows shade during the warmer summer months when there is foliage, and solar penetration during the winter months when there is leaf loss.

The effect of air movement increasing heat gain/loss through building facades can also be mitigated by green walls, thus helping in the lowering of building energy usage. The increased thermal performance can lower energy requirements for the heating or cooling of a building, and thus lower greenhouse gas emissions.

3.2 Reduction of Urban Heat Island

The **evapotranspiration** from living walls also contributes to the lowering of temperatures around the planting. A study of 56 planter boxes on 4 floors of the Institute of Physics in Berlin showed they achieved a mean cooling value of 157kWh per day. (Schmidt, Riechmann and Steffan, 2006, 3).

In warmer temperatures, when a building envelope is covered with vegetation such as green roofs or walls, the surrounding air temperature can be decreased, which not only leads to energy savings for cooling building interiors, but also to the lowering of the UHI. Alexandri suggests that a temperature decrease of maximum 8.4°C in an urban canyon (5-10m high and 5-15m wide) in humid Hong Kong could be achieved if both walls and roofs were covered with vegetation when measured on a typical day of the hottest month for that city – in this case, with a diurnal air temperature range of 27ºC minimum and 32 ºC maximum. (Alexandri, 2006).

The lack of vegetation in dense urban environments coupled with the heat reflected off hard surfaces of both high rise buildings and streets and paving contributes to higher temperatures within cities. With growing interest in incorporating living walls into building design, this could affect the microclimate of cities thus lowering the urban heat island temperatures. Alexandri's study concludes that temperatures lowered by green walls and green roofs can "bring temperatures down to more 'human-friendly' levels and achieve energy saving for cooling buildings from 32 per cent to 100 per cent" (Alexandri, 2006).

3.3 Positive Effects on Hydrology

Studies show that green roofs contribute positive improvements to urban hydrology because they can successfully control sudden discharge of stormwater to the sewers. This delay of run-off can similarly be realised through percolation of rainfall through living walls although there is no data yet on the amount of rainwater that can be managed in this manner.

Many interior living walls collect irrigation run-off from the wall to re-circulate through it again with added nutrients. The current drought has increased our awareness of water conservation, and thus many living walls in Australia are irrigated with recycled rainwater or grey/blackwater (e.g. CH2 in Melbourne). The ability of living walls to thrive with non-potable water and the retention of significant run-off on-site offers real benefits to urban stormwater management.

3.4 Improvement of Air Quality

Many interior living walls are built to improve indoor air quality and are sometimes called bio-walls. Through bio-filtration, carbon dioxide (CO^2) and harmful toxins such as Volatile Organic Compounds (VOCs) are absorbed through both the plants and planting medium as indoor air is drawn through the living wall (Darlington, 1998).

Research conducted by the University of Guelph, Canada shows that "a biofilter with living botanical matter as the packing medium reduced concentrations of toulene, ethylbenzene, and *o*-xylene concurrently present…" (Darlington, 2001). This research showed that plants,[1] (refer to the plant list in Notes section of the appendix), together with their growing medium removed significant amounts of VOCs from indoor air with varying results at different temperatures. The study also concluded that establishment of large bio-walls in a relatively air-tight indoor space with a low 0.2 ACH (Air Changes per Hour) compared to 15 to 20 ACH, and with 30 per cent fresh air content,registered slightly higher airborne microbial spore counts when compared to other indoor spaces within the building but were within reported ranges for other buildings (Darlington, 2000). Spores within range are thought to be not harmful to human health.

NASA research from 1985 showed the ability of some plants to filter and absorb atmospheric pollutants such as benzene and n-hexane. Similar research has also been carried out in Australia to show the high performance of several indoor plants (Wood, 2003). Refer to the plant list in the Notes section of the appendix for further information.

3.5 Reduction of Noise Pollution

Leaves are not known for their sound absorption qualities (Haron 2007) but plants and their planting medium may be effective as sound barriers, as seen on many highways. Their effectiveness for sound attenuation has to be extrapolated at this stage from green roof research and would mainly come from the planting medium. Living wall systems can be of benefit to reduce sound reflection from the hard surfaces of roads and buildings in increasingly denser cities.

3.6 Increasing Urban Biodiversity and Urban Food Production

Living walls can be a means to increasing biodiversity in urban environments where much ecology has been lost to development. Increased native flora and fauna species have been documented by green roof projects and it is not unreasonable to expect similar results for vertical landscapes.

There is also interest in the possibility of growing food on living walls. Although there does not seem to be a commercial venture at this point, there are viable proposals such as Knafo Klimor Architects' Agro-Housing project planned for Wuhan in China, which proposes to create a vertical greenhouse where families can grow food close to their living quarters. (Klimor, 2008). Green space-frame walls with diverse uses such as provision of nesting areas for species, food production, terrariums and energy sources have also been proposed by author Dr Janis Birkeland, to be retrofitted onto existing buildings. (Australian Institute of Architects: BEDP EDG, 2007)

3.7 Improvement of Health and Well-being

The increasing interest in incorporating living walls into the built environment attests to our inclination towards having more greenery within our habitable surroundings. Benefits associated with improved working environments stem from research linking proximity of nature to faster patient recovery and lower office absenteeism. (Kellert, 2005). Recent surveys administered to office workers in the USA and Norway revealed that employees who worked in office environments with interior plants or window views reported higher job satisfaction (Dravigne, 2008 and Bringslimark, 2007).Australian Institute of Architects, BEDP EDG, 2008)

As more acknowledgement is given to this benefit, many green building designers are encouraged to incorporate the **biophilic** properties of living walls as part of a sustainable design strategy that responds to our complex relationship with the natural environment, which is otherwise being eroded, as we live in increasingly dense urban surroundings.

Living walls are an emerging technology that can also be used successfully in our increasingly dense urban environments to promote outdoor living and walkability in cities, as their added greenery can lower ambient temperature and moderate the harsh nature of many of our urban structures..

4.0 ELEMENTS OF A LIVING WALL

4.1 Orientation

As with any planting design, orientation and climate determine the choice of appropriate plant species for the living wall. Plants grown at the top of a wall will have different light, air movement and moisture conditions than those located near the bottom or lower parts of the wall. It is important to understand these microclimatic conditions as well as the amount of light required for plant survival, especially in indoor conditions which may require supplementary light.

4.2 Plant Selection

Several plants that have thrived in living walls in Australia for the past few years include epiphytes, lithophytes, bromeliads, ferns, succulents, climbers and grasses. Native plants as well as ornamental species have also been successfully used. Most of the plant species that have been tested for their **phytoremedial** qualities have been indoor plants. Refer to Notes 1 and 2 in the appendix for more detail.

As the concept of living walls is still relatively new in Australia, there is no public database of plants listing their suitability for use in exteriors or interiors, and research is warranted in this area, especially for Australian plants. The plant choices are influenced as much by local microclimatic conditions and orientation as by the availability of local plant stock. A sample of native and ornamental plants currently used by local suppliers of living walls in Australia is provided.[3] Refer to the plant list in the appendix for more detail.

4.3 Irrigation

As living walls are basically hydroponic systems where water and nutrients are fed to the wall via some means of mechanical irrigation, it is important to establish control and timing of the watering system. It is prudent to ensure a secure and regular water supply with backup generators in case of power failure. The Centre for Subtropical Design advocates the use of non-potable water such as recycled water or collected rainwater. The two living walls in Melbourne City Council's CH2 building and Lendlease's Melbourne headquarters are designed to use recycled grey and black water.

There are examples of some proprietary living wall systems in Canada and Australia that have been successfully designed to be part of an ecological system, where aquatic plants and fish inhabit a pond at the bottom of the wall from which the water is drawn back to the top of the wall to be reused in the cycle.

4.4 Maintenance

Designing a building with an early understanding of living walls can greatly reduce maintenance costs. With the exception of access and regular watering issues, local suppliers state that maintenance of a living wall should be no more onerous than that of landscape planting. Designing the living wall as a pivoting or removable screen can reduce the use of lift equipment to maintain living walls that are placed high on a building.

The usual requirements of pruning, feeding and watering still apply though in a different way. Establishing a well-understood maintenance regime with facilities management personnel, especially at the specification stage, will greatly improve the likelihood of survival of the wall.

4.5 Building Design Integration

Many trades can be involved in the implementation of a living wall. Early identification by the designer of which trades are needed, and in what way, will enable smoother coordination during construction.

Planning for the inclusion of external living walls in a project at the initial design stages provides greater flexibility for the design of the façade, structural supports and mechanical watering system, and thus reduces the cost of implementation. When designing exterior living walls, consideration should be given to accessibility for maintenance, solar access for internal spaces, and visual amenity to building occupants.

Similarly, if interior living walls are designed for air quality purposes, then their connection to the mechanical ventilation systems need to be purposefully designed.

4.6 Costs

Current data on the cost of living walls generally only indicates the capital outlay and the operational cost of their maintenance, without indicating the potential for lowering of building energy costs due to their shading/insulative properties,and increased workplace productivity.

By integrating living walls during the initial design stages and creatively designing them as part of the façade or using them in lieu of sunscreens, it is possible to minimise their cost and maximise their benefits.

5.0 CONCLUSION

Living walls are an emerging technology with few established large commercial examples in Australia at the time of writing this paper. However, the success of living walls in countries such as France, Japan, Singapore, the USA and Canada has inspired many local designers to consider living walls in recent building projects.

The growing volume of international research data revealing the positive outcomes of living walls such as the lowering of surface building temperature and urban heat islands, improving urban hydrology and indoor air quality, etc, may increase the confidence of many designers to consider using this technology in Australia. The ability of a living wall to offer a more pleasant, healthier and more productive workplace together with lower building energy bills, are incentives that should have particular appeal to both building owners and developers.

Living walls currently being built in Australia will yield data in the near future as to the suitability of plants for our climate and the success of irrigation using non-potable water.

Due to the many positive benefits of living walls, they are gaining interest from designers as a new building technology that can help improve our urban environment as well as lower greenhouse gas emissions. Living walls are a new green way to address climate change and an emerging technology that offers a new way to green the built environment.

GLOSSARY

Biophilic or biophilia: refers to our natural human affiliations to nature. This aspect of human psychology has been studied by Erich Fromm (1964) and E.O. Wilson (1984).

Biofiltration: A means of removing air pollutants by passing a building's exhaust air through a biofilter that usually consists of a hydroponic living/green wall with microbial planting medium. The microbes are able to convert the pollutants into less harmful components of water and carbon dioxide. The cleaned air is then redistributed to the rest of the building via a mechanical ventilation system.

Evapotranspiration: describes evaporation from both plant and soil surfaces and transpiration (evaporation of water from plants when they 'breathe' or transpire)

Phytoremediation: The process in which plants are able to absorb pollutants thus helping to decontaminate soil, water and air.

REFERENCES

Alexandri, E. and P. Jones (2006) Temperature decreases in an urban canyon due to green walls and green roofs in diverse climates. *Building and Environment* 43(4): 480-493.

Australian Institute of Architects, 2007, *BEDP Environment Design Guide,* 'GEN 4: Positive Development – Designing for Net Positive Impacts', Australian Institute of Architects, Melbourne.

Australian Institute of Architects, 2008, *BEDP Environment Design Guide,* 'GEN 79: Impact of Indoor Environment Quality on Occupant Productivity and Wellbeing in Office Buildings', Australian Institute of Architects, Melbourne.

Bass, B., and B. Baskaran. 2001. Evaluating Rooftop and Vertical Gardens as an Adaptation Strategy for Urban Areas. *National Research Council of Canada NRCC-46737*. http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc46737/nrcc46737.pdf (accessed 8 Aug 2008).

Bringslimark T., T. Hartig and G. Patil (2007) Psychological benefits of indoor plants in workplaces: Putting experimental results into context. *Hortscience* 42(3): 581-587

CH2 Melbourne – vertical gardens watering system http://www.melbourne.vic.gov.au/info.cfm?top=171&pa=4112&pa2=4091&pg=4077#vertical (accessed 8 Aug 2008).

Darlington, A., J. Dat and M. Dixon. (2001) The Biofiltration of Indoor Air: Air Flux and Temperature Influences the Removal of Toulene, Ethylbenzene, and Xylene. *Environmental Science & Technology* 35(1): 240-246

Darlington, A., M. Chan, D. Malloch., C. Pilger and M. Dixon (2000) The biofiltration of indoor air: Implications for air quality. *Indoor Air* 10(1): 39-46

Darlington, A., MA Dixon and C Pilger. 1998 The use of biofilters to improve indoor air quality: the removal of toluene, TCE , and formaldehyde. *Life Support Biosphere Science* 5(1): 63-69

Di, H. and D. Wang (1999) Cooling Effect of Ivy on a Wall. *Experimental Heat Transfer* 12(3): 235-245

Dravigne, A., T. Waliczek, R. Lineberger and J. Zajicek 2008 The effect of live plants and window views of green spaces on employee perceptions of job satisfaction. Hortscience 43(1): 183-187

Haron, Z. and DJ Olham. 2007. *A Markovian approach to the modelling of sound propagation in urban streets containing trees. Conference on Sustainable Building South East Asia*. Nov 2007. Malaysia.

Hoyano, Akira. 1988. Climatological Uses of Plants for Solar Control and the Effects on the Thermal Environment of a Building. *Energy and Buildings* 11(1998): 181-199

Kellert, S. 2005. Building for Life: Designing and Understanding the Human-Nature Connection. Island Press, Washington, D. C.

Kim, KJ, MJ Kil, JS Song, EH Yoo, KC Son and SJ Kays (2008) Efficiency of volatile formaldehyde removal of indoor plants: Contribution of aerial plant parts versus the root zone. *Journal of the American Society for Horticultural Science* 133(4): 521-526

Knafo Klimor architects – winner of Living Steel China 2007 Sustainable Design competition with their Agro-Housing proposal. http://www.knafoklimor.co.il/living-steel/index.html (accessed 02 Sep 2008)

Mallany J., A. Darlington and M. Dixon The Biofiltration of Indoor Air II: Microbial Loading of the Indoor Space from the Controlled Environment Systems Research Faciltiy at the University of Guelph. http://www.ces.uoguelph.ca/research/envweb/Publications.htm (accessed 20th Aug 2008)

NASA Scientific and Technical Information. Plants Clean Air and Water for Indoor Environments http://www.sti.nasa.gov/tto/Spinoff2007/ps_3.html (accessed 20th August 2008)

Orwell R., R Wood, J. Tarran, F. Torpy and M. Burchett (2004) Removal of benzene by the indoor plant/substrate microcosm and implications for air quality. *Water Air and Soil Pollution* 157(1-4): 193-207

Schmidt, M., B. Reichmann and C Steffan. 2006. Rainwater harvesting and evaporation for stormwater management and energy conservation. *Berlin State Department for Urban Development.* http://209.85.141.104/custom?q=cache:T9vgnOj4nigJ:www.stadtentwicklung.berlin.de/bauen/oekologisches_bauen/de/downloads/SchmidtReichmannSteffan13.pdf+rainwater&hl=de&ct=clnk&cd=4&gl=de or http://www.stadtentwicklung.berlin.de/bauen/oekologisches_bauen/de/downloads/SchmidtReichmannSteffan13.pdf (accessed 8 Aug 2008).

Wood, R. 2003. *Improving the indoor environment for health, well-being and productivity. Greening cities: a new urban ecology*. April 2003. Sydney : Australian Technology Park. http://www.aila.org.au/nsw/greeningcities/papers/proc_wood.pdf

Wood, R., M. Burchett, R. Alquezar, R. Orwell, J. Tarran and F. Torpy (2006) The potted-plant microcosm substantially reduces indoor air VOC pollution: I. Office field-study. *Water Air and Soil Pollution* 175(1-4): 163-180

Wood, R., R. Orwell, J. Tarran, F. Torpy and M. Burchett (2002) Potted-plant/growth media interactions and capacities for removal of volatiles from indoor air. *Journal of Horticultural Science & Biotechnology* 77(1): 120-129

BIOGRAPHY

Susan Loh, B. Arch., B. Arts (hons) is a lecturer at the School of Design, Queensland University of Technology, Brisbane, and a researcher of Living Walls with the Centre for Subtropical Design, QUT. (www.subtropicaldesign.bee.qut.edu.au/projects.html)

Susan has worked in architectural firms in Australia and Canada for ten years in aged care, commercial buildings and residential projects. Her main areas of academic research and teaching involve sustainability, environmentally responsive buildings and Living Walls. She can be contacted at susan.loh@qut.edu.au.

APPENDIX – NOTES AND RESOURCES

NOTES

Bio-wall

[1] The bio-wall in the Darlington study consisted of a rock vertical face covered with about 2cm thick mosses such as *Plagiomnium cuspidatum* and *Taxiphyllum deplanatum*. The principal plant species that were hydroponically grown included *Dracaena godseffiana, Adiantum raddianum, Hedera helix, Spathiphyllum maunahoa, Rododendron obtusum, Marraya sp., Vriesea splendens* and *Dieffenbachia picta*. At the base of this living wall, was an aquarium using recirculated water and containing aquatic plants such as *Elodea sp., Cabomba sp.*, and *Vallisneria sp.* and semi-aquatic plants such as *Cyperus spp., Myriophyllum prosperindacoides,* and *Lysimachia sp.* (Darlington, 2001).

Plant Species

[2] Some interior plants that have been tested at the University of Technology, Sydney were Kentia Palm *(Howea forsteriana)*, Peace Lily *(Spathiphyllum 'Petie')*, 'Janet Craig' *(Dracaena deremensis)*, *Dracaena marginata,* Devil's Ivy *(Epipremnum aureum)*, Queensland Umbrella Tree (*Schefflera actinophylla* 'Amate') and *Spathiphyllum 'Sensation'*. (Wood 2003)

[3] Sample of Plants used in living walls in Australia include natives and ornamentals:

- Epiphytes and Bromeliads: *Aechmea distichantha; Alcantera glaznouiana; Billbergia amoena v. viridis; Canistropsis bilgergoides; Neoregelia fosteriana; Tillandsia araujei; Pticairnia;*
- Lithophytes: *Dendrobium speciosum*
- Hemicrytophytes such as *Acorus graminifera*
- Ferns: *Adiantum* and *Platycerium superbum*
- Grasses: Black *(Ophiopogon planiscarpus 'Nigrescens')* and Green Mondo; *Liriope variegated*
- Ornamentals /Perennials: *Heuchera; Chlorophytum comosum; Begonia; Veronica; Cerastium; Trachelospermum; Viola Hederacae* and *Pelagoium*
- Herbs: mint, rosemary, thyme, tarragon, chives and oregano

CASE STUDIES

Panel System

Overseas:

Vancouver Aquarium, Canada
http://www.greenroofs.org/index.php?option=com_content&task=view&id=1036&Itemid=136

Bio-Lung,, Aichi Expo 2005, Japan http://www.japanfs.org/db/1029-e

Local:

Lend Lease Corporate Headquarters, Melbourne http://www.greenwall.com.au/project11.htm
Frankston private hospital, Victoria http://www.fytogreen.com.au/Fytowall/projects.htm

Felt System

Overseas:

Living wall at Museé du Quai Branly, Paris designed by Patrick Blanc:
http://www.verticalgardenpatrickblanc.com/

Local:

Qantas First Class Lounges, Sydney and Melbourne airports designed by Patrick Blanc
http://www.abc.net.au/rn/bydesign/galleries/2007/2043831/ and
http://www.specifier.com.au/projects/hospitality/30025/Marc-Newson-s-Qantas-First-Lounge.html

Gazebo Wine Garden restaurant, Sydney http://www.greenwallaustralia.com.au/

Container and/or Trellis System

Overseas:

Singapore Management University:

photo can be viewed from: www.zulanas.lt/images/adm_source/docs/2-MakYewCheong_paperENG.pdf and brief article: www.smu.edu.sg/news_room/smu_in_the_news/2006/sources/ST_20060107_3.pdf

Local:

CH2, Melbourne:

www.melbourne.vic.gov.au/info.cfm?top=171&pa=4112&pa2=4091&pg=4077#vertical

Ferry Road Markets, Southport, Gold Coast:
www.architecture.com.au/awards_search?option=showaward&entryno=2007040529

Interior Living Walls

Overseas:

University of Guelph, Toronto, Canada
www.raic.org/honours_and_awards/awards_raic_awards/2005recipients/award5_e.htm and
www.inhabitat.com/2005/07/19/living-wall/

Queen's University, Kingston, Canada http://livebuilding.queensu.ca/green_features/biowall

Local:

see Qantas First Class Lounges and Lend Lease examples above

FURTHER READING

Living walls research at the Centre for Subtropical Design, Queensland University of Technology
www.subtropicaldesign.bee.qut.edu.au/projects.html

Both Green Roofs Australia greenroofs.wordpress.com and Green Roofs for Healthy Cities USA have information on Living/Green Walls www.greenroofs.org

Hopkins, G (2006) Bushtops and Living walls, a Winston Churchill Memorial Trust fellowship report
www.churchilltrust.com.au/res/File/Fellow_Reports/Hopkins%20Graeme%202005.pdf

Johnson, C (2004) Greening cities: landscaping the urban fabric, Sydney, NSW: Government Architect's Publications, Sydney.

Dunnett, N. & Kingsbury, N (2004) Planting green roofs and living walls, Timber Press, Cambridge, UK.

Lambertini. A, (2007) Vertical gardens: bringing the city to life, London, UK, Thames & Hudson

Urban Agriculture online http://www.urbanag.org.au/index.html