International
Specialised
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Institute Inc

PRATT FOUNDATION

GREEN ROOFS AND VERTICAL GARDENS

Sidonie Carpenter

The Pratt Foundation/ISS Institute Overseas Fellowship

Fellowship supported by The Pratt Foundation

ISS Institute Inc.
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Please consider the environment before printing this report. *Wherever possible during the course of Sidonie Carpenter's trip and the writing of this report she has sought to achieve a carbon neutral footprint. 'Green Roofs for Healthy Cities' conference achieved a zero carbon footprint. Neutralising the greenhouse gas emissions resulting from the production and distribution processes and travel.*

Executive Summary

By 2005, 50% of the world's population lived in cities (Bindé, 1998), and in the industrialised world, the figure has already surpassed 80%. The growth in urban populations has and will continue to create a unique set of environmental problems, both within cities and in the surrounding areas, due to the large demands for food, energy and water. Many of these problems are either directly caused, or exacerbated by the removal of vegetation to accommodate urban expansion. It is expected that many of these problems will be further affected by climate change, particularly impacts that contribute to heat waves and the associated health problems, rapid temperature changes, stormwater runoff, water quality, biodiversity and food security.

Green roofs and vertical gardens have never been widely recognised or understood in Australia; hence we have a very limited knowledge and skill base for their design and implementation. It is an area that offers many diverse applications with outcomes that directly benefit the client and the environment, while giving the industry a competitive edge and future growth.

Ford Motor Plant – Dearborn, Michigan. The biggest green roof in the world at 10. 4 acres

Green roofs offer a number of environmental benefits, both to the public and private sectors.

What are the benefits of Green Roofs?

- Aesthetically pleasing
- Reduction of the Urban Heat Island effect

  The envelope of hot air that hovers over cities due to heat reflective material and the lack of vegetation is known as the 'Urban Heat Island' effect. It is the aggregate of all the heat absorbed and generated by buildings, roads, vehicles, HVAC systems, etc., and can result in cities being as much as 7 to 10 degrees warmer than their suburban and rural counterparts….LBNL (Lawrence Berkeley National Laboratory) scientists indicate that widespread heat-reduction measures, such as planting rooftop vegetation, could easily lower a city's temperature by five degrees.

- Reduction of carbon dioxide - greenhouse effect

  Carbon Dioxide/Oxygen Exchange is through the process of photosynthesis, plants convert carbon dioxide, water and sunlight/energy into oxygen and glucose. This cyclical process supplies animals and humans with oxygen and food.

- Reduction of air pollution

  1 m^2 of grass roof can remove between 0.2 kg of airborne particulates from the air every year.

Executive Summary

- Reduction of heating and cooling loads

  ...can reduce heating and cooling requirements by as much as 20 to 30 percent for a one story structure. Cutting energy consumption. A three to seven degree temperature drop translates into a 10% reduction in air conditioning requirements.

- Lengthen roof life by two to three times

  ...can last twice as long as standard roofs, the life expectancy of waterproofing is increased to more than 40 years. Increased life expectancy of the membrane because it is better protected from mechanical damage, UV-rays, hail and extreme temperature differences.

- Reduction of sound reflectance and transmission

  Tests have shown that green roofs can reduce indoor sound by as much as 40 decibels, providing particular benefit to buildings in noise impacted areas, such as those close to airports or industry.

- Reduction of rainfall run off impacts

  In Germany alone, more than 1.8 million square metres of new green roofs are installed every year. Many cities require green roofs for buildings in districts that are plagued by chronic runoff related problems…. a typical green roof with about 100mm of growing media can be designed to reduce annual runoff by more than 50 percent.

Ref - Green Roofs for Healthy Cities. Green Roof Design 101 Introductory Course. 2nd edition, 2006

Schiphol Airport – extensive green roofs

Germany - Stuttgart rooftops

Germany - Berlin rooftops

Green roofs and vertical gardens can help reduce some of the impact that urbanisation imposes on the environment and our quality of life. This is being successfully achieved in a number of areas in the world, specifically Europe and North America. There is a need to investigate how this is achieved and then adapt and apply this knowledge and skill to Australian conditions.

Identified skills gaps:

- Understanding what a green roof is and its benefits
- Different green roof systems
  - Modular
  - Loose laid
- Budget development and cost estimation
- Green roof standards
- Specifications

Executive Summary

- Basic design parameters
  - Access
  - Structural load bearing
  - Sloped roofs
- Installation
  - Waterproofing
  - Drainage systems
  - Irrigation
  - Growing media
  - Vegetation
  - Maintenance
- Design and installation team selection
- Education and training
- Liability and system warranty

The Fellowship program took Carpenter to Singapore, the United States and Canada and encompassed many site visits, both planned and impromptu, to green roofs and vertical gardens. Meetings were held with individuals and councils involved at all levels of green roof design, implementation, maintenance, promotion and education. Carpenter also attended the 'Green Roof for Healthy Cities' conference and completed two green roof specific design and implementation courses.

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Abbreviations and Acronyms

AILA	Australian Institute of Landscape Architects
AILDM	Australian Institute of Landscape Design and Managers
CPSISC	Construction and Property Services Industry Skills Council
GRA	Green Roofs Australia
GRHC	Green Roofs for Healthy Cities
ISSI	International Specialised Skills Institute
UHI	Urban Heat Island (UHI effect)
VOC	Volatile Organic Chemical
WGRIN	World Green Roof Infrastructure Network

Acknowledgments

Sidonie Carpenter would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide her throughout the Fellowship program.

Specific Acknowledgements

Carolynne Bourne AM, CEO, ISS Institute, and Jeanette McWhinney, Program Manager, Fellowships, Events and Training at ISS Institute.

Awarding Body - International Specialised Skills Institute (ISS Institute)

We know that Australia's economic future is reliant upon high level skills and knowledge, underpinned by design and innovation.

The International Specialised Skills Institute Inc (ISS Institute) is an independent, national organisation, which has a record of nearly twenty years of working with Australian industry and commerce to gain best-in-the-world skills and experience in traditional and leading-edge technology, design, innovation and management. The Institute has worked extensively with Government and non-Government organisations, firms, industry bodies, professional associations and education and training institutions.

The Patron in Chief is Sir James Gobbo AC, CVO. The ISS Institute Board of Management is Chaired by Noel Waite AO. The Board comprises Franco Fiorentini, John Iacovangelo, Lady Primrose Potter AC and David Wittner.

Through its CEO, Carolynne Bourne AM, the ISS Institute identifies and researches skill deficiencies and then meets the deficiency needs through its *Overseas Skill Acquisition Plan (Fellowship Program),* its education and training activities, professional development events and consultancy services.

Under the Overseas Skill Acquisition Plan (Fellowship Program) Australians travel overseas or international experts travel to Australia. Participants then pass on what they have learnt through reports, education and training activities such as workshops, conferences, lectures, forums, seminars and events, therein ensuring that for each Fellowship undertaken many benefit.

As an outcome of its work, ISS Institute has gained a deep understanding of the nature and scope of a number of issues. Four clearly defined economic forces have emerged out of our nearly twenty years of research. The drivers have arisen out of research that has been induced rather than deduced and innovative, practical solutions created - it is about thinking and working differently.

A Global Perspective. 'Skills Deficiencies' + 'Skills Shortages'

Skill deficiencies address future needs. Skill shortages replicate the past and are focused on immediate needs.

Skill deficiency is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas. This is the focus of the work of ISS Institute.

There may be individuals or firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass way. Firms likewise come and go. If Australia is to create, build and sustain Industries, knowledge/skills/understandings must be accessible trans-generationally through nationally accredited courses and not be reliant on individuals.

Acknowledgments

Our international competitors have these capabilities as well as the education and training infrastructure to underpin them.

Addressing skill shortages, however, is merely delivering more of what we already know and can do to meet current market demands. Australia needs to address the ***dual*** challenge – skill deficiencies and skill shortages.

Identifying and closing skills deficiencies is vital to long-term economic prospects in order to sustain sectors that are at risk of disappearing, not being developed or leaving our shores to be taken up by our competitors. The only prudent option is to achieve a high skill, high value-added economy in order to build a significant future in the local and international marketplace.

The Trades

The ISS Institute views the trades as the backbone of our economy. Yet, they are often unseen and, in the main, have no direct voice as to issues which are in their domain of expertise. The trades are equal, but different to professions.

The ISS Institute has the way forward through its 'Master Artisan Framework for Excellence. A New Model for Skilling the Trades', December 2004. The Federal Government, DEEWR commissioned ISS Institute to write an Australian Master Artisan School, Feasibility Plan.

In 2006, ISS Institute Inc. set up a new ISS advisory body, the **Trades Advisory Council.** Members are Ivan Deveson AO; Martin Ferguson AM, MP, Federal Labor Member for Batman; Geoff Masters, CEO, Australian Council of Educational Research; Simon McKeon, Executive Chairman, Macquarie Bank, Melbourne Office; Richard Pratt, Chairman, Visy Industries and Julius Roe, National President Australian Manufacturing Workers' Union.

Think and Work in an Holistic Approach along the Supply Chain - Collaboration and Communication

Our experience has shown that most perceive that lack of skills is the principal factor related to quality and productivity. We believe that attitudes are often the constraint to turning ideas into product and a successful business; the ability to think laterally, to work and communicate across disciplines and industry sectors, to be able to take risks and think outside the familiar, to share – to turn competitors into partners.

Australia needs to change to thinking and working holistically along the entire Supply Chain; to collaborate and communicate across industries and occupations - designers with master artisans, trades men and women, Government agencies, manufacturers, engineers, farmers, retailers, suppliers to name a few in the Chain.

'Design' has to be seen as more than 'Art' discipline – it is a fundamental economic and business tool for the 21st Century

Design is crucial to the economic future of our nation. Australia needs to understand and learn the value of design, the benefits of good design and for it to become part of everyday language, decision making and choice.

Design is as important to the child exploring the possibilities of the world, as it is to the architect developing new concepts, and as it is to the electrician placing power points or the furniture designer working with a cabinet-maker and manufacturer. As such, design is vested in every member of our community and touches every aspect of our lives.

Our holistic approach takes us to working across occupations and industry sectors and building bridges along the way. The result has been highly effective in the creation of new business, the development of existing business and the return of lost skills and knowledge to our workforce, thus creating jobs - whereby individuals gain; industry and business gain; the Australian community gains economically, educationally and culturally.

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Fellowship Sponsor - The Pratt Foundation

The Pratt Foundation was established in 1978 by Richard and Jeanne Pratt with the shared vision of supporting charitable enterprises and adding value to philanthropy. The Foundation is now one of the largest private sources of philanthropy in Australia. In the words of its mission statement, it aims “to enrich the lives of our community” and, in the words of Jeremiah, it works to fulfil this aim in a spirit of “kindness, justice and equity”.

Carpenter would like to thank them for providing funding suport for this Fellowship.

Fellowship Supporters

- Green Roofs Australia
- Geoffrey Pie Architect, Brisbane Australia
- Simon Squire, Landscape Logic, Brisbane Australia
- Sally Gosse, Multiplex Australia
- Anthony Pie, Mirvac Australia
- Daniel Richards, The Plant Specialists
- Richard Jones Landscape Architect, Brisbane Australia
- Tammy Fahy, for her patience and support with editing

In addition, Carpenter would like to acknowledge the support of her business, *Sidonie Carpenter Landscape Design*, in providing the time and the additional funding required to undertake the Fellowship and associated activities. She would also like to thank her family for their ongoing support, enabling her to fulfil this Fellowship.

Organisations

Organisations Involved in the Development of the Overseas Program

- Green Roofs Australia
- Elmich
- The Plant Specialists

Australian Organisations Impacted by the Industry

Government

- Federal, State and Local

Green Roofs Australia

Business Commerce Firms – Design and Development

- Multiplex - Multiplex was founded in 1962 in Perth, Western Australia, by John C Roberts AO. Multiplex has grown strongly over the last four decades and has thrived through a number of different property and economic cycles. Multiplex is a fully integrated property business who develop, build, manage and own property. They have a keen interest in sustainable design and construction and its value to the construction industry.

Acknowledgments

- Mirvac - This group's development division is responsible for some of Australia's best residential projects and currently has approximately 30,000 lots under its control that will be progressively developed over the next 8-10 years. An undisputed leader in its field, Mirvac is committed to the provision of exceptional service, outstanding developments, and sound investment opportunities, which incorporate cutting edge design options and ideas.
- Investa - Investa is engaged in residential and commercial development. Investa's residential division, Clarendon Residential, encompasses broad acre sub-divisional home building. Commercial Developments undertake development of industrial, commercial and retail property.

  Investa is a world leader in sustainability and up until its delisting in September 2007, upon becoming a subsidiary of MSRE, was rated number one on the Dow Jones Sustainability World Index (DJSI) in both the real estate sector and the financial services super-sector and was also included in the 'Global 100' most sustainable companies in the world.

Professional Associations – Institutes

- Australian Institute of Landscape Architects (AILA)
- Royal Australian Institute Architects (RAIA)
- Australian Institute Landscape Designers and Managers (AILDM)

Education/Training institutes

The findings of the Fellowship will be of significance to these education and training institutes:

- Queensland University of Technology, Built Environment & Centre for Sub Tropical Design
- TAFE institutes
- Universities

About the Fellow

Name: Sidonie Carpenter

Employment

- Principal Designer and Owner, Sidonie Carpenter Landscape Design

Education

- Cert IV in Fine Arts, Meadowbank TAFE, Sydney Australia
- Adv Cert Urban Horticulture, OTEN
- Graduate Diploma Landscape Architecture, QUT, Brisbane, Australia
- Bachelor Arts, University QLD, Brisbane, Australia
- Bachelor Science – Coastal Management University, New England, Northern Rivers

Positions

- Vice President – Green Roofs Australia. www.greenroofs.wordpress.com

Sidonie Carpenter had a creative and stimulating childhood surrounded by art and design which ultimately inspired her to study Landscape Architecture and Horticulture; a career that has allowed her to run her own business for the past 12 years.

Running her own business has been very rewarding. She has always maintained a very hands-on approach, allowing the combination of her design skills and horticultural knowledge to provide a holistic approach. As a result, she has been able to work on jobs both big and small, from historic gardens to new developments and from coast to country. With her work always being site and client specific, Carpenter tends not to follow any particular style or trend but rather focuses upon creating a successful design and horticultural solution that considers the client's brief within the context of environmental issues such as aspect, water, soil and species selection.

Environmental issues and the impact they are having on the future of Australia's cities, specifically the issue of water management, need close attention and action. The impact that this will have across the Landscape Industry as a whole has inspired Carpenter to consider alternatives that will create sustainable design options. This in turn has led to an interest in rooftop and vertical gardens, their design and environmental benefits.

Aims of the Fellowship Program

The aim of this Fellowship was to explore the role and implementation of rooftop and vertical gardens. This study focused on design and construction methods in order to optimise the aesthetic and environmental aspects of domestic design.

Specific Areas of Study and Development

- General design, recommendations for residential and retro applications.
- Understand the construction requirements – materials, growing media, water management, drainage and species selection.
- Research the environmental impact – Urban Heat Island effect, water management, energy consumption and air quality.

Ongoing Areas for Development

- Investigate and collate information on scientific research specific to environmental and health benefits.
- Explore strategies to promote benefits of rooftop and vertical gardens to Government, Developers, Architects, Landscape and Education.
- Create a marketing and promotional model which can be adopted Australia-wide.
- Develop ongoing education programs through ISS Institute, QUT, TAFE, Green Roofs Australia and other educational institutions.
- Develop strategies to promote rooftop and vertical garden design options in property development.
- To work with Government in developing policy and legislation and with appropriate Industry Skill Councils.
- Research plant species suitable to Australian Green Roofs.

The results of this Fellowship aim to explore the direct implications of rooftop and vertical gardens on the urban environment. Furthermore, it aims to provide effective strategies for the design and implementation of these gardens in Australian cities.

The Australian Context

A Brief Description of the Industry

Australia has a very well established landscape design and construction industry. However, to date there has been little development in the area of rooftop or vertical garden design. This is an area of considerable research potential.

As we see Australian cities experience more pressure from urban growth, we need to look at and utilise rooftop and vertical spaces to bring the natural environment and all its benefits back into the urban landscape.

Extensive scientific research from Europe, America and South East Asia emphasises the benefits of green roofs and should be used to promote the benefits of rooftop and vertical gardens in Australia.

Australia has extreme climatic conditions, and as a result of this much research and knowledge is required to provide the design and construction industry with the information needed to install sustainable green roofs and vertical gardens.

An increase in interest from the design and construction industry and a greater understanding of the benefits of rooftop and vertical gardens should impact upon Government policies. The increase in implementation within the Australian urban environment will make the technology and infrastructure more accessible.

As a result of the lack of information, knowledge and skills in this highly specialised area, construction costs have been particularly high. It is hoped that in developing these areas, associated costs will be reduced.

Green Roofs Australia (GRA) has been established to begin Australia's entry into important global networking and information exchange with 15 other national green roof organisations that make up the World Green Roof Infrastructure Network (WGRIN).

In cities where land is valuable and scarce, we must begin to think creatively to increase and restore the urban environment. Bare rooftops can be green open spaces without altering the land use or compromising development.

There is an excellent opportunity to extend skills and knowledge to target interest groups within the Design and Construction industries.

DPI (Department of Primary Industries), Queenscliff, Victoria – Lyons Architects

Identifying the Skills Gap/s

Definition - Skill Deficiencies

As established previously, **skill deficiency** is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas. This is the key area targeted by ISS Institute and this Fellowship.

Certainly, there may be individuals or individual firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass way. Firms likewise come and go. If Australia is to create, build and sustain 'Industries', knowledge, skills and understandings must be accessible across the generations through nationally accredited courses and not reliant on individuals.

Identifying and Defining the Gap/s

Planting on roofs and vertical surfaces is one of the most quickly developing fields in landscape design and the built environment. In Europe and North America green roofs are now proven technology to help counter adverse effects of climate change. With increased urbanisation, the associated Urban Heat Island effect and depleted water resources, there is a need to study and understand the design requirements of both new and retro fitted rooftop gardens for the Australian built environment.

Central to any discussion are the following two issues:

1. The opportunity to explore the relationship and impact that pollution from urban development has on the environment and the economy and to observe the positive effects roof gardens have in helping to alleviate this problem.
2. Education is the key to implementing long-term changes. Environmental issues regarding water, pollution, and increasing temperatures are at the forefront of our daily lives.

Green roofs and vertical gardens can help reduce some of the impact that urbanisation imposes on the environment and our quality of life. This is being successfully achieved in a number of areas in the world, specifically Europe, and North America. There is a need to investigate how this is achieved and then adapt and apply this knowledge and skill to Australian conditions.

Identified Skills Gaps:

- Understanding what green roofs are and their benefits
- Different green roof systems
  - Modular
  - Loose laid
- Budget development and cost estimation
- Green roof standards
- Specifications
- Basic design parameters
  - Access
  - Structural load bearing
  - Sloped roofs

Identifying the Skills Gap/s

- Installation
  - Waterproofing
  - Drainage systems
  - Irrigation
  - Growing media
  - Vegetation
  - Maintenance
- Design and installation team selection
- Education and training
- Liability and system warranty

Why it Needs to be Addressed

Currently the tangible pubic and private benefits of green roofs are undervalued. Green roof technologies need to be brought to the forefront of high performance, restorative green building design, implementation and maintenance. Given the many benefits of green roof technology the Australian green roof industry is poised for rapid growth over the next decade. It is on this basis that a need has been clearly identified to increase awareness of the economic, social and environmental benefits of green roof infrastructure across Australia and advance the development of the market for green roof products and services.

The International Experience

The Fellowship program encompassed many site visits, both planned and impromptu, to green roofs and vertical gardens. Meetings were held with individuals and councils involved at all levels of green roof design, implementation, maintenance, promotion and education. Carpenter also attended the 'Green Roof for Healthy Cities' conference and completed two green roof specific design and implementation courses.

The Destination and Objective

Singapore, United States and Canada.

Businesses/Firms

Elmich PTE LTD, Singapore – Alan Tan, Sales Manager, and Michael HB The, Director

Retro fitting in the tropics/species selection/green wall species & construction options/ drainage importance. Examples of work:

- Aramsa Garden Spa
- Singapore School of Art and Design
- Hort Park Research Nursery

Plant Specialists, New York – Daniel Richards, Landscape Architect

Design components/waterproofing/construction options/maintenance. Examples of work:

- Lauder House
- Kipps Bay
- Plant Specialists

Toronto City Council – Ilze Andzans, Toronto Water, and Jane Welsh, City Planning

Toronto Green Roof Pilot Program 'Making Green Roofs Happen'.

Site Visits

- Singapore Botanic Gardens – green roof and wall design and plant selection
- Aramsa Garden Spa, Singapore – retro fitting/species
- Singapore Polytechnique School of Art and Design – design/drainage
- Singapore Hort precinct Test Nursery – plant species/growing methods
- Getty Center, Los Angles – design/species
- Theodore Alexander Jr. Science Center School, Los Angles – design
- Phyto Universe, New York – green wall design/construction/species/maintenance/lighting
- Fordham University, New York – design/species/integration
- Brooklyn Botanic Gardens, New York – sustainable design/species
- Queens Botanic Gardens, New York – sustainable design
- Socrates Sculpture Park, New York – education/community
- Silver Cup Building, Balmori and Associates, New York, – Landscape Architects Design/ research/plant species/construction
- Kipps Bay House, Plant Specialists, New York – plant species/construction
- Lauder House, Plant Specialists, New York – construction

The International Experience

- Plant Specialists Office, Green Roof, New York – Construction/design/maintenance/species
- Mountain Equipment Store, Toronto – David Robinson, Ecological design/community/species/costing/maintenance
- Toronto Sheraton Green Wall, Toronto – design/species
- Robertson Building, Bio Filter, Toronto – design/species
- Lincoln Park Zoo, Chicago – community/design/education
- Peggy Notebart Nature Museum, Chicago – community/design/education
- Apple Store, Chicago – design/species/policy
- Millennium Park, Chicago – design/species/policy/construction
- Minneapolis Library, Minneapolis – design/species/construction
- Cancer Survivors Park, Minneapolis – design/species
- Brits Pub, Minneapolis – design
- Union Square, San Francisco – design
- Sasaki Design Group, San Francisco – design/constraints/environment
- California Academy of Science, San Francisco – design/species/education

Conference

Greening Rooftops for Sustainable Communities, Minneapolis MN. April 29 - May 1 2007

This conference was organised by Green Roofs for Healthy Cities (GRHC) a not-for-profit industry association working to promote the green roof industry in North America.

The three-day conference consisted of plenary and specialised sessions focussing on four main topic areas:

1. Policies and programs to support green roofs
2. Green roof design and implementation
3. Research and technical papers on green roof performance
4. Networking & information forums on current green roof topics

The conference was designed for architects, landscape architects, roofing professionals, green roof researchers, horticulturalists, urban planners, facility managers and developers, policy makers and anyone with an interest in green roofs and green buildings.

> *"Solutions! The rapidly growing green roof industry provides tangible solutions to the many challenges facing cities so we are pleased to welcome you to the Fifth Annual International Greening Rooftops for Sustainable Communities."*
>
> *"Exhibitors, volunteers, speakers, delegates, this conference provides a unique opportunity for you to share, learn, network, do business and have fun, while contributing to a new living architecture. An architecture that blends the organic and inorganic, the living and non-living, into beautiful, restorative and healing buildings. Clearly this is the way forward and we thank you for being on this path with us."*
>
> Peter Lowitt, Chair, Green Roofs Healthy Cities

The International Experience

Conference Program:

Track 1

Session 1.1 Stormwater Policy Development

Session 1.2 Development of Green Roof Standards and Policies

Session 1.3 Feasibility and Impact Assessments of Green Roofs Programs

Track 2 – Case Studies and Design

Session 2.1 Green Roofs in Minnesota and Chicago

Session 2.2 Stormwater Management and Life Cycle Calculation

Session 2.3 Green Roof Design Case Studies

Session 2.4 Innovative Uses of Green Roofs

Session 2.5 Green Walls and Green Roof Gardens

Track 3 – Research on Technical Performance Benefits

Session 3.1 Stormwater Management and Other Benefits of Green Roofs

Session 3.2 Stormwater Research

Session 3.3 Energy and Thermal Performance

Session 3.4 Green Roof Growing Medium and Vegetation

Session 3.5 Studies on the Benefits of Green Roofs

Courses/Workshops

- Green Roof Design 101: Introduction Course. Patrick Carey, Hadj Design – Minneapolis
- Green Roof Infrastructure: Design and Installation 201 – Virginia Russell, University of Cincinnati

Individuals

- Wolfgang Ansel, Director, IGRA, Singapore Botanic Gardens – planning, execution and upkeep of green roof sites
- Michael The, Elmich, Singapore – green roof and vertical garden design and development
- Alan Tan, Elmich, Singapore – green roof and vertical garden sales
- Laurent Corradi, New York – vertical garden technology
- Geoffrey Bruce, Geoffrey L Bruce and Company, Chicago – Landscape Architect specialising in green roof design and construction
- Daniel Richards, Plant Specialists, New York – Landscape Architect, rooftop gardens

Outcomes - Overview of Green Roofs

Green roof infrastructure has become a multi-million dollar industry in Germany and is gaining popularity in North America, Canada, Singapore and Australia. Green roof infrastructure is more than just soil and plants on a roof, but consists of specialised membranes and drainage barriers to support the growing of vegetation on top of buildings. Many of the advantages of these technologies, such as the reduction of stormwater runoff, the reduction of cooling loads and the reduction of the Urban Heat Island effect suggests that this technology could play a role in helping cities adapt to climate change.

A green roof is a contained green space on top of a human made structure below, above or at grade. Each green roof is unique and often designed to achieve multiple objectives and performance results.

As the potential benefits of green roofs are more widely recognised, the interest in green roof technology has increased. Twenty-first century green roof technology employs a multilayer system, including a waterproof membrane, drainage layers, specialised soil medium, soil stabiliser, and a selection of appropriate plant species and varieties that best tolerates the often extreme environmental conditions found in a rooftop setting. The current interest in green roofs is coming to the forefront due to their potential to alleviate several environmental problems common to urban areas as follows:

Storm Water Runoff

In urbanised regions, natural areas well adapted to capturing storm water are replaced with impervious surfaces, such as roadways or buildings. Consequently, during major storm events water quickly runs off of these impervious streets and rooftops, burdening storm sewers, treatment plants, and nearby streams and lakes. Compared to traditional roofing materials, green roof systems detain, filter, and slowly release storm water, reducing the peak flows and overall volume of runoff.

By installing green roofs, some natural storm water control benefits are regained. If widely implemented, green rooftops have the potential to reduce storm water runoff and nonpoint source pollution problems in urban and suburban environments.

Urban Heat Island Effect

Most cities are largely constructed of concrete, asphalt, and brick - materials that all absorb and store heat during the day. Conventional roof surfaces also absorb heat and some have been reported to reach temperatures up to 80ºC. The re-radiation of this heat from the building structures can cause air temperatures in large cities to be as much as 12-14°C higher than surrounding suburban and rural areas, an effect that is particularly evident at night. This phenomenon is known as the ‘Urban Heat Island’ effect. As a result of the warmer temperatures, air conditioning use rises, putting summertime strains on local electricity distribution grids. Green roofs can help reduce the Urban Heat Island effect, as transpiring plants lower air temperatures, soil and vegetation trap and absorb much less heat than conventional tar or shingle roofs, and retained storm water allows for the benefits of evaporative cooling.

Air Quality

Warmer Urban Heat Island temperatures also exacerbate air pollution, contributing to the formation of smog and ozone. Warm air updrafts from hot surfaces can circulate fine particulates and degrade air quality. These increases in air pollution increase the risk of health complications, and reduce the quality of life for the millions of urban citizens.

Green roofs indirectly help alleviate these air pollution problems. Plants on rooftops could contribute directly to enhanced air quality by trapping and absorbing nitrous oxides, volatile organic compounds, and particulates.

Energy Conservation

By providing shading, insulation, and evaporative cooling, green roofs can lower energy use and costs, particularly on the top floor of buildings. Green roofs are most effective where the roof of the structure is flat or slightly pitched, and the roof represents a significant portion of the building surface area. Moreover, rooftop garden plants located near intakes for air conditioning systems will transpire, lowering the temperature of incoming air and reducing costs to cool the building's air supply. The additional insulation provided by the green roof materials could even cut energy use and costs during winter.

Urban Wildlife Attractant

The green roof technologies promote an active growth medium to support the vegetation. In turn, this vegetation provides the habitat for additional wildlife, from pollinators to songbirds.

Reduced Material Use

Green roof manufacturers/installers claim that their products will last at least forty years, versus the 10-15 year life span of a conventional roof. This reduces maintenance/ replacement costs and the material use.

Public Space

With limited land space available in cities, rooftop gardens can increase public amenity space at no additional land cost.

Categories

There are two basic categories of green roof infrastructure – extensive and intensive. Both categories have different characteristics.

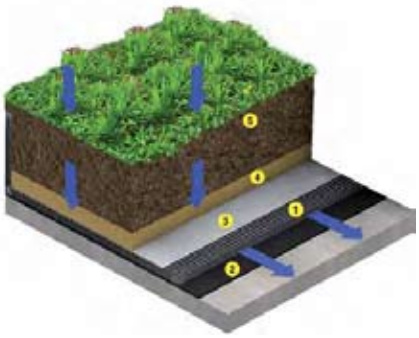
CHARACTERISTIC	EXTENSIVE	INTENSIVE
Growing Medium Depth	150mm or less	> 150mm
Accessibility	Often inaccessible	Usually accessible
Fully saturated weight	Low 48.8 – 170kg/m^2	High 244 – 1500 kg/m^2
Plant diversity	Low	Greatest
Cost	Low	High
Maintenance	Minimal	Varies, but is generally high

Characteristics of Extensive and Intensive Green Roofs

The International Experience

Extensive roof structure – ref: Elmich

1. Waterproofing membrane
2. Drainage cell
3. Geotextile
4. Web structure (sloped roof)
5. Growing media



Intensive green roof structure – ref: Elmich

1. Drainage cell
2. Waterproofing
3. Geotextile
4. Growing media
5. Growing media

Extensive green roof retrofit – Aramsa Spa, Singapore

Millennium Park – Chicago

EXTENSIVE	**INTENSIVE**
Light weight	Greater diversity of plants
Suitable for large areas	Best insulation properties and storm water management
Low maintenance costs and may be designed for no irrigation	Greater range of design
More suitable for retrofit projects	Usually accessible
Lower capital costs	Greater variety of human uses
Easier to replace	Greater bio diversity potential

Advantages of different Green Roof Categories. Ref – Green Roof Design 101: Introductory Course. Green Roofs for Healthy Cities.

The International Experience

Different Green Roof Systems

Modular – these systems combine two or more essential components of a green roof assembly into one product, providing a one-stop shop approach to green roof design and implementation.

These systems may be flexible (eg. plant species seeded into a woven fabric) or firm (eg. metal or recycled plastic containers).

Modular systems are used most often in extensive green roofs applications. They are usually pre-planted and/or assembled off site to be transported and installed quickly and easily.

Typically they are laid directly above the waterproofing layer, they allow for easy system alterations/repairs and quick access to the underlying roof surface. When pre-grown, they create an immediate aesthetic impact.

Loose Laid – the separate installation of various essential components of green roof assembly, with products supplied by one or more firms. Loose laid systems can be used for all types of green roof projects and are often selected for very large projects.

Loose laid systems offer extra flexibility, greater design opportunities and may have cost advantages on larger projects.

The various components of the green roof assembly are laid on top of one another. Green roof installation requires the services and coordination of multiple professions. Different sub-contractors may assume responsibility for one or more layers of the systems.

Modular system – Green Grid

Loose laid system

Budget Development & Cost Estimation

There are infinite possibilities for green roof design. No two green roofs are the same and each needs to have the costs and benefits calculated individually. There are many variables that influence the capital and maintenance costs of green roofs:

- Retro fit vs new construction
- Access
- Maintenance requirements
- Market place

Green roofs typically require higher upfront capital cost than a traditional roof; these costs are usually paid back over the life cycle of the building.

Cost factors are aspects of the project that are usually controlled by the design team. Costs in Australia will fall just like they have in the US and Germany with increased demand, technical material and machinery as well as with the development of a skilled workforce.

The International Experience

ELEMENT	PRICE RANGE	COST FACTORS
DESIGN	4 - 8% project cost	Size and complexity of job
PROJECT ADMIN/ SITE REVIEW	6 - 12% project cost	Size and complexity of job and number of professionals involved
INITIAL STRUCTURAL EVALUATION	$6,000 - $50,000 retrofit or new project/size	New vs existing building, and quality and detail of documentation
(RE) ROOFING WITH HIGH QUALITY MEMBRANES	$0 - $250/m depending on roofing type. New membrane $140- $250/$m^2$ depending on type & application	Types of components, size, accessibility and number of roof penetrations
DRAINAGE	$20 - $200/m	Type of drainage layer, installation method, and size of project
FILTER CLOTH	$20 - $60/$m^2$	Type of cloth and size of project
GROWING MEDIUM Depending on mix & del.	Extensive $40 - $250/$m^3$ Intensive $40 - $400/$m^3$	Volume/type/shipping and method of conveyance to roof (crane, manual, blower)
VEGETATION Backup ordering or contract growing	Extensive $0 - $100/$m^2$ Intensive $25 - $200/$m^2$	Type and size of plants, time of year, seeds, cuttings, mats, shrubs, trees – containers, anchorage, method of conveyance to roof
INSTALLATION	Extensive $48 - $130/$m^2$ Intensive $48 - $300/$m^2$	Size of project, sophistication of design, type of planting, and access
MODULAR GREEN ROOF SYSTEM Including plants, growing medium and root repellent layer – not yet available in Australia	Extensive $200+/$m^2$ Intensive $260+/$m^2$	Sophistication of design, shipping, installation, plant species and density
STRUCTURAL REINFORCEMENT OF EXISTING ROOF	Cost dependent on existing structure	May not be necessary. Consult structural engineer to determine the load carrying capacity of the roof
EROSION PROTECTION LAYER	$0 - $10/$m^2$	May not be necessary if growing medium is not left exposed or vegetation is well established
CURBS/BORDERS	$0 - $120/m	May not be necessary. Type (concrete pavers, natural stone, aluminium edging, wood, gravel, timber, recycled products) and length
WALKWAYS	$0 - $120/m	May not be necessary (concrete pavers, natural stone, aluminium edging, wood, gravel, timber, recycled products) and length
RAILINGS	$0 - $400	May not be necessary. Material, (aluminium, brass, wrought iron, steel, timber etc) thickness, number, and roof deck penetration depth
MAINTENANCE	Extensive $10 - $80/$m^2$ for first 2 years. Intensive $80 - $160/$m^2$	Size of roof, types of plants, and nature of access
IRRIGATION SYSTEM	$0 - $30/m	May not be necessary. Type of irrigation system used and size of project

Green Roof Cost Ranges & Factors. Ref – Green Roof Design 101: Introductory Course. Green Roofs for Healthy Cities. Due to the industry in Australia being new, prices have been taken from US examples & products. Costs will vary due to regional differences & availability of product.

The International Experience

Incentives

Supportive public and private policy programs encourage green roof implementation. The number of policy programs being implemented in cities and states around the world is growing rapidly. Incentives for these programs maybe direct or indirect with some cities making green roof construction mandatory (eg Tokyo, Japan)

Direct Incentives

- Density bonus
- Fast track permits
- Green space allocation
- Green Star rewards
- Direct investments/grants

Indirect Incentives

- Low interest loans
- Energy efficiency
- Storm water rebates

The Australian Green Roof Industry is still in its infancy. There is a need for research and public policy support both on a state and local scale. Further research to help quantify the benefits and characteristics of the Australian Green Roof Industry is required.

Photovoltaic integrated design - Germany

Bowling Green – Brits Pub, Minneapolis

Green Roof Standards

Standards and guidelines lay down the general requirements and provide the basis for agreement between clients, planners and contractors.

Because the Green Roof Industry in Australia is in its infancy existing standards and guidelines could be checked to see how applicable they are generally, or whether or not they can be used in a modified form.

The validity and statutory significance of the specific instructions issued by the manufacturers in respect to various materials needs to be carefully considered.

The existing materials standards need to be considered and followed. For example, there may already be standards in place not specifically looking at green roofs:

The International Experience

- General terms for building works
- General regulations governing construction works of all types
- Landscaping work
- Damp proofing
- Water proofing
  - Definitions, different types
- Structural design loads
  - Bedding materials, construction materials and structural components, intrinsic loads and friction angles
  - Live loads
  - Live loads; wind loads
  - Live loads; snow and ice
- Drainage
  - Construction
  - Maintenance
- Construction materials under fire
- Thermal insulation
- Sound insulation
- Playing fields
- Vegetation in landscaping
  - Ground works
  - Plants
  - Lawns and seeding
  - Care & maintenance

Specifications

Specification must describe the system being constructed, including maintenance information.

Maintenance specifications can be used to develop the maintenance plan. The execution of maintenance is crucial for the success of green roof projects.

There are 4 kinds of specifications:

- Descriptive specifications detail the methods and materials used in construction
- Performance based specifications lay out the attributes of the materials used but allow the contractor to source and select products, so long as they meet the performance requirements
- Proprietary specifications cite a manufacturer's product
- Reference specifications draw on existing standards

In North America, cities such as Chicago, Toronto, Minneapolis and Portland have established programs that have, or will lead to more widespread green roof implementation. Within each of these municipalities none of the current green roof performance standards set by an independent standard body have been legally integrated into the Building Codes with the exception of Chicago's Green Building/Green Roof Matrix.

When designing and installing all green roofs they should be built to local codes and ordinances under the guidance of existing guidelines and standards.

Basic Design Parameters

Access

Access needs to be considered for construction, maintenance and as a design element if it's designed for pedestrian amenity.

Construction – the primary concern relates to health and safety issues, that is the method of getting the material to site and onto the roof.

Maintenance – maintenance crews will require access to the roof, these must meet the local job safety and building code requirements.

Pedestrian – access must observe local building code safety requirements. These may include balustrades, fire safety, disabled access, and lighting.

Structural Load Bearing

The structural load must be calculated by an engineer. There are two types of load that must be considered: dead load and live load.

Dead load includes all permanent materials (growing medium, water proofing, plants, gravel, paving, irrigation. Live loads are not constant and are affected by things such as wind, rain, people, and temporary equipment.

Calculations must take into account:

- Plant weight at maturity
- Fully saturated growing medium
- Fully saturated drainage layers
- Weight of all system components
- Areas of spot loading

Structural load is one of the definitive design constraints and will determine:

- Access
- Function
- Plant selection
- Growing medium depth & composition
- Material transport & installation
- Maintenance and repairs

Sloped Roofs

Green roofs on slopes greater than a 10º pitch are more difficult to implement because you must take into account gravity and shear force.

Green roof installation is not recommended on slopes greater than 40º. Engineered slope stability is required for roof pitches greater than 10º.

Installation

Waterproofing

Waterproofing is the area that is responsible for the most litigation. The quality and installation method of the waterproofing can jeopardise the integrity of the green roof, the roofing systems, the building and its occupants.

If properly designed and installed the green roof will protect and prolong the life of the roof membrane.

Waterproofing assemblies consist of various components and must be integrated in design and installation:

- Structural deck – the structure of the building and the deck type will determine waterproofing design and installation.
- Membrane – there are many kinds available each with pros and cons. In specifying a membrane it is important for the specification to include an appropriate method of leak detection and also when it must be used (eg prior to installation of green roof system). The membrane must be brought above the growing medium level along walls and parapets to protect from moisture ingress.
- Membrane protection – Protection can be either as a separate layer or as part of another system which then serves two purposes (eg drainage layer). It is important to increase protection in areas of high traffic during construction.
- Root barrier – Some membrane products have a root retardant added. If not, then a root barrier should be installed across the entire roof and brought up above the finished level of growing medium.
- Flashings – Poorly installed flashings represent up to 70% of all roofing problems. Flashings should be integrated and designed to allow for maintenance.
  - Flashings must be high enough to render them watertight under extreme weather conditions.
  - Membrane flashings should be raised to accommodate green roof materials while still protecting the roof from moisture.
  - Copper or stainless steel flashings are suggested when built into the membrane.
  - Aluminium is not recommended due to its reaction to fertiliser.

Drainage Systems

The purpose of drainage systems is to facilitate water runoff from the roof to prevent structural collapse and plants from drowning while retaining enough moisture to support plant life.

Green roof drainage should be integrated into the building drainage system and on-site water management strategy. These systems need to be designed for storms in accordance with local codes and regulations.

Drainage systems need to be permanent and cover the entire roof surface. They should include redundancy features such as overflow drains.

All drains should sit at the surface of the growing medium and have a vegetation free zone. Water retention may be desirable as an environmental mandate. This may require:

- Increased drainage cup size
- A water retention layer
- Engineered growing medium

Irrigation

All green roofs require irrigation for the first few years to get the plants established, even those designed to be irrigation free. Green roofs that do require irrigation should be designed to be water efficient. The source of water needs to be considered at the design stage.

The use of harvested and grey water will reduce the environmental impact of the green roof and integrate the building systems. Irrigation system should be site specific with the following potential design parameters:

- Size
- Pressure and flow
- Quality
- Plant requirements
- Climate
- Growing medium
- Maintenance
- Slope

Water should be conserved using automatic systems incorporating water sensors. The watering system should be based on the plants' needs rather than arbitrary schedules. It is also very important to protect the waterproofing layer during installation

Client and maintenance education is also very important. Green roofs are living and will change with the seasons like any garden. Species selection will affect the drought impact, irrigation requirements and growth rates.

Growing Medium

Growing medium selection is critical to the long and short term success of a green roof. Factors to consider:

- Load bearing capacity
- Slope
- Climate
- Drainage
- Plant species

Failure to consider these elements could result in:

- Structural collapse
- Slumpage
- Plant loss
- Weed growth and maintenance issues
- Compaction and erosion/lack of water management

Vegetation

Plant selection has ramifications for the entire green roof design. Plant species must be considered from the initial stages of design. Plant selection is dependent on a number of factors:

- Client budget
- Maintenance investment and resources
- Aesthetics
- Function
- Climate and weather
- Structural load bearing
- Roof type
- Plant growth rates and nutrient demand
- Supply and availability

The International Experience

"When considering plants for green roofs, one must satisfy many environmental and design constraints. Plants must be matched to the roof location for both macro and microclimatic conditions. A professional horticulturalist, landscape architect or local nursery should be consulted for this information and to help select plants that meet the client's needs". Snodgrass, 2004

School of Art & Design, Nanyang Technical University, Singapore – by Elmich

Depth	**Inaccessible/ Invisible**	**Inaccessible/ visible from a far distance**	**Inaccessible/ visible from a close distance**	**Accessible**
0-5cm	Simple sedum/moss communities	Simple sedum/ moss communities	Simple sedum/ moss communities	Simple sedum/moss communities
5-10cm		Dry meadow communities, low growing drought tolerant perennials, grasses and herbs	Dry meadow communities, low growing drought tolerant perennials, grasses and herbs	Dry meadow communities, low growing drought tolerant perennials, grasses and herbs
10-20cm				Semi-extensive mixtures of low to medium dry habitat perennials, grasses and annuals, small shrubs, lawn, turf and herbs
20-50cm				Medium shrubs, edible plants, perennials and grasses
50+ cm				Small trees, shrubs, and grasses

Plant Selection & Accessibility/Visibility Objectives for the Roof (Dunnet & Kingsbury 2004)

Maintenance

All roofs, green or conventional, need maintenance. One of the main causes of green roof failure is the lack of proper maintenance for the first 5 years. Maintenance is crucial for a green roof to live up to the claim that it will prolong the life of the waterproofing membrane.

Owners must be aware of the maintenance requirements and the responsibility and commitment to ensuring the continued success of the green roof. A five year maintenance contract should be established. Roof replacement strategies should be included, setting out procedures for the storage of and care of vegetation and growing medium during repairs, space and load bearing capacity permitting.

Design & Installation Team Selection

The selection of a strong team of construction trades and specialists will help to ensure the smooth installation process.

Construction contracting depends on a variety of factors:

- Budget
- Size
- Green roof category
- New or retrofit
- Complexity – degree of building integration
- Bidding or Negotiation – problems may occur due to:
  - Unrealistic expectations – budget or schedule
  - Ambiguity in design
  - Lack of contractor experience
  - Contractor price error
  - Lack of complete understanding of project
  - Lack of qualified foreman
  - Poor communication
- It is recommended that a pre-bid conference is held on site for the owner and design team to clearly communicate information, technical or procedural, to bidding contractors. Pre-bid conferences can reduce confusion and facilitate better bids.

Education & Training

Pre-construction training benefits all trades involved in the installation of a green roof. Understanding the 'other trades' responsibilities will facilitate better coordination, reduce errors and save money. Points that should be considered are:

- Coordinate the trades
- Discuss scheduling, logistics, staging, requirements
- Emphasise communication & define common objectives
- Safety plan
- Understanding of risks and responsibilities with each trade
- Outline mechanisms for problem resolution

Liability & System Warranty

In order to minimise liability all contractors involved in the green roof construction process should be diligent about record keeping and documentation.

Limiting Liability – points for consideration:

- Acquiring design expertise
- Managing client expectation
- Prudential practice – documentation/specifications
- Understanding design, project goals and materials
- Specifications based on demands of the site rather than cost
- Appropriate insurance cover
- Educating the client

Warranties – A warranty or guarantee may provide protection for the client against defective products or workmanship. All warranties should be discussed at the initial meeting between owner, contractor and manufacturing representative to ensure all parties are aware of the conditions and requirements.

Outcomes - Green Walls & Vertical Gardens

Types of Green Walls

There are two general types of green wall systems - *green façades* and *living walls*.

Green façades are trellis systems or training structures installed for climbing plants to grow vertically without attaching to the surface of the building. Living walls are a building envelope system where plants are actually planted, irrigated and grown in a modular system secured and integrated to a wall.

In France, the botanist Patrick Blanc, developed the 'mur vegetal', a type of living wall that covers entire façades like a canvas of lush foliated plants.

In Canada, Dr. Alan Darlinton, invented the bio-filtration wall ('bio-wall'), which improves indoor air quality by removing toxic VOCs (volatile organic chemicals) and CO^2. http://www.naturaire.com/index.html

Les Halles – Paris. By Patrick Blanc

Phyto Universe Spa – New York

The International Experience

Most of the green wall systems installed in North America and Europe to date are green façades that feature training systems that support vines growing upward from the ground or grow in elevated containers. Modular trellis panels and stainless steel cable systems hold climbing plants away from the surface of the building. The foliage of the climbing plants reduces solar heating, most effectively on walls that face the sun. The leaves are effective at trapping dust and pollutants in the air.

Clinging vines such as English Ivy and other aggressive species attach directly to wall surfaces without support, however they are not recommended for new developments because of potential surface damage and increased building maintenance.

Green Walls in Japan

To mitigate the Urban Heat Island effect, the Federal Government of Japan and various cities offer major incentives for developers to install green façades, living walls and green roofs. Tokyo suffers from poor air quality and climate change. The average temperature is now 5 degrees F (3°C) higher than it was 30 years ago. On tall buildings, the ratio of wall surface to roof area is much higher.

The Government of Japan funded the installation and research for the Bio Lung, a 500' long by 40' high green wall complex. The Bio Lung demonstrates 30 different green wall systems supplied by 18 different manufacturers in Japan. During the 1990s, Japanese municipalities and Federal Government agencies realised that concrete high-rises are the dominant form of urban development, which is contributing to the Urban Heat Island effect. Enacted in April 2001, the Tokyo Metropolitan Government (TMG) requires that all rooftops and wall surfaces be greened on new construction projects with a footprint greater than 1,000m^2 (250m^2 for public facilities).

Benefits of Green Walls

Green walls reduce the surface temperature of buildings by as much as 10°C when covered with vegetation and a growing medium. In 1979, green wall research by Akira Hoyano (Professor, Tokyo Institute of Technology), a pioneer in passive and low-energy architecture, revealed that the heat energy that passed through a green wall was significantly lower than a concrete wall… It was also concluded that green wall panels reduce energy transfer into a building by ~0.24kWh/m.

Green wall energy calculations depend on wall orientation, sun angle, wind flow and microclimate around the building. Multiple benefits also include improved air quality, acoustics, health and well-being, and reduction of building deterioration by UV (ultraviolet) rays.

The green wall and building envelope is designed as a complete system. Many systems are installed on a frame to allow air space behind the green wall. In some applications, a waterproof membrane is required to protect the building unless a high-density concrete is used in the structural wall.

Green walls along with planted rooftops:

- reduce the Urban Heat Island effect
- cool ambient temperatures
- filter the air, and
- provide habitat

Green walls can be successful indoors and externally. For indoor success artificial lighting is required with the plant species selection according to the environment and climate.

Knowledge Transfer: Applying the Outcomes

The Green Roof Industry in Australia is in its infancy and it is essential to ensure that opportunities are provided for knowledge transfer and exchange. To support and encourage the growth of a sustainable industry the following activities have been identified:

- February 2008, 2nd annual 'Green Roof Conference', Brisbane. Providing local and international green roof knowledge and case studies. Targeting industry, affiliated associations, Government and education.
- February 2008, (in conjunction with conference), presentation of training course – Green Roof introductory course.
- February 2008, (in conjunction with conference), 'Green Roof Tour' of new and completed green roofs in the Brisbane area.
- Development of Green Roofs Australia website: www.greenroofs.wordpress.com
- 'Green Roof Pilot Program' in conjunction with support from Brisbane City Council to select nine potential sites for the implementation of green roofs, new and retro fit.
- Seminar – 'Introduction to Green Roofs' targeted at affiliated associations, to share design and construction knowledge and support the growth of a well educated Green Roof Industry.
  - Griffith University Eco Centre, Brisbane – June 18, 2007
  - AILDM seminar, Sydney – 18th September 2007

Green Roofs Australia - an affiliated association, was founded in February 2007. Sidonie Carpenter (ISSI Fellow) currently sits as Vice President to be President after the 2008 conference.

Chicago City Hall – extensive green roof

Recommendations

Government - Federal, State, Local

Recommendations:

- Carpenter is available to discuss her report with the Construction and Property Services Industry Skills Council (CPSISC) so that CPSISC can incorporate her findings into appropriate courses and levels of training within the National Training System.
- Understanding what a green roof is and the benefits – education support and provision aimed at general public up to industry professionals.
- Green roof standards – inclusion of standards into the current building code and recognition by the Green Building Council of Australia.
- Green roof policy – grass roots understanding of green roof benefits and its position within Local Government policy.
- Australian test and research study – support and construction of local green roof research and development sites to provide local facts and figures.
- Education and training – funding and support of a training program for a better understanding of what a green roof is and what it does. Inclusion into the TAFE and University syllabus at both trade and professional levels.
- Pilot Program – commitment to manage a green roof pilot program to increase local awareness of green roofs and provide long term research and development sites.
- Providing regional green roof data will allow investors to make informed decisions and local planning commissions to create financially feasible policies that enhance the urban environment. Currently, green roofs are widely used in Europe, and interest is expanding in major North American cities such as Chicago, New York, Toronto, Vancouver, and Portland.

Industry / Professional Associations

Recommendations:

- Understanding what a green roof is and the benefits, through education provided via the CPSISC, industry associations, Government training programs/incentives or tertiary courses and education.
- Budget development and cost estimation – a part of training and education and the development of a skilled and sustainable Green Roof Industry
- Specifications – growth of the industry and provision of green roof products onto the Australian market in combination with education and training into the specifics of green roof design and construction via Government education, tertiary education, association training programs, conferences and seminars.
- Basic design parameters – education and knowledge.
- Installation – availability of green roof products on the Australian market, training of installation skills.

Education and Training - University, TAFE, Schools

Recommendations:

- Understanding what a green roof is and its benefits
- Different green roof systems
- Budget development and cost estimation

- Green roof standards
- Specifications
- Basic design parameters
- Installation
- Design and installation team selection
- Liability and system warranty

Writing and implementation of specific green roof components to both trade (waterproofing, horticulture, and irrigation) and professional courses (architecture, engineering, and landscape architecture).

Providing specific and relevant education will see the development and growth of new industries and trades under the green roof banner, helping to build and maintain a sustainable and well educated industry.

The Process as a Learning Experience for the Profession

Green roofs should be recognised as an emerging market opportunity for the design and construction industry. The primary mission of the green roof industry should be to promote the advancement of green roofs through advocacy, education, and communication. Each project is an opportunity to embrace this mission and draw upon the talents of its many industry members. A collective and inclusive process provides educational opportunities for members and insight into this market segment.

The installation of any green roof should be viewed as an opportunity for public education and continued learning. An educational aspect of a green roof could include exhibits, monitoring, and testing to further awareness and understanding to supplement public education and communication.

Limited quantifiable information is available about the performance and benefits of green roof technology. The primary vehicle to expand professional knowledge is scientific inquiry. All projects should serve as a research platform to expand the industry's understanding and advocacy of green technologies. Partnerships with University programs should be explored to monitor the long term green roof impacts and benefits whenever possible.

Community

The level of knowledge about green roofs and walls in Australia is limited. This is changing rapidly as the current climate issues promote environmental benefits of infrastructure such as green roofs.

The Government needs to support this growth with the implementation of policy, bonus systems, education and research and development. This support could come via the introduction of education modules, a green roof pilot program, association conferences and Government incentives for green roof installation.

The green roof industry is in need of standard methods of analysis and the development of performance-based specifications. An analytical approach focuses on the critical elements of system performance, not on product branding. Of interest are the new green roof material standards being developed by American Society of Testing and Materials (ASTM) E-06 Committee. The academic community has also shown interest in the topic. Penn State University and University of North Carolina have established green roof quality control laboratories which can certify performance of materials as well as complete systems.

Recommendations

Project Opportunities

A green roof project of visibility and focus provides opportunities and challenges far beyond the processes of design and installation. Green roof projects represent a commitment to an ethic of sustainability and offer a symbol of leadership to the profession in a growing and evolving movement and consciousness. Equally important is the visibility to the general public. Many green roof projects will be the focus of significant media attention and discussion. Any green roof should not only be the result of the efforts of one property owner, but must serve to capture the imagination of the public. A design solution should not only be recognised for advancing green roof technology, but it should reflect an aesthetic of integrated design and sustainability. As always, these challenges are indeed opportunities.

ISS Institute Inc.

- Contact and introductions with TAFE and Universities
- Media and publicity to promote information and attract funding for further Fellowships (see Further Skills Gaps).
- Workshops

Further Skills Gaps

There are further skills gaps that will become apparent at the time of specification writing right through to installation and supply of materials. Because green roofs are a unique and specialised area the number of industries and professions associated with the design and installation process is huge. This presents individual skill gaps in each specific area:

- **Client:** General education and knowledge to understand the benefits of a green roof, the design and construction process and realistic expectations.
- **Architect:** Understanding the integrated nature of green roofs, specifications, grants, permits, cost estimation, construction compliance with plans, contractor relationships.
- **Landscape Architect:** As this was the focus of Carpenter's Fellowship, the skills gaps for Landscape Architects have been extensively covered in this report.
- **Structural Engineer:** Loading requirements and capacity, load distribution during construction, structural safety.
- **Civil Engineer:** Drainage and utilities.
- **Environmental Engineer:** Impact of green roofs on the surrounding environment.
- **Roofing Consultant:** Selection and installation of roofing system, waterproofing, insulation, flashing, drainage systems.
- **Green Roof Professional:** As covered in this report.
- **Growing Medium Consultant:** Specific composition of green roof growing medium, structural load bearing weights, advice on profile depth and performance.
- **Horticulturalist:** Plant selection specific to each site, plant availability, fertility and maintenance regime, quality control of plant material.
- **Landscaping Contractor:** Installing drainage, irrigation, growing medium, plant material, procuring materials, collaborating with other trades, maintenance.

Emerging technologies have led us to a new perspective and definition of the meaning of successful and appropriate 'Green Technologies'. This re-definition has opened the doors to a more complex and diverse practice area for the design profession that will become pre-eminent in the next decade.

Recommendations

The diverse issues shaping the discussion of viable agronomic systems in the urban fabric must continue to be pursued if we are to be successful in our leadership of the sustainable movement. This pursuit will guide the industry toward meeting our environmental responsibilities and project a broader meaning for green roofs into the urban fabric.

As more green roofs are retrofitted to existing roofs and integrated into new buildings, roofing and landscape contractors will become more expert at their installation and will be able to streamline their costs. When construction costs of green roofs are lowered, the manufacturing industry feeding them will expand and become more competitive. The installation of green roofs will then become less expensive and more routine – green roofs could become a standard building practice. A key aspect to this entire process is getting the public interested in sustainable technology.

"There has never been another single product that can positively impact immediate environmental, economic, health and social concerns. Green roofs provide a wide range of positive effects for buildings, inhabitants, and the environment. Thus, ***Green Roofs meet one of the essential conditions of sustainable development, the reconciliation between economy and ecology.****"*

George Irwin, CEO for Rochester based Green Living Roofs, LLC

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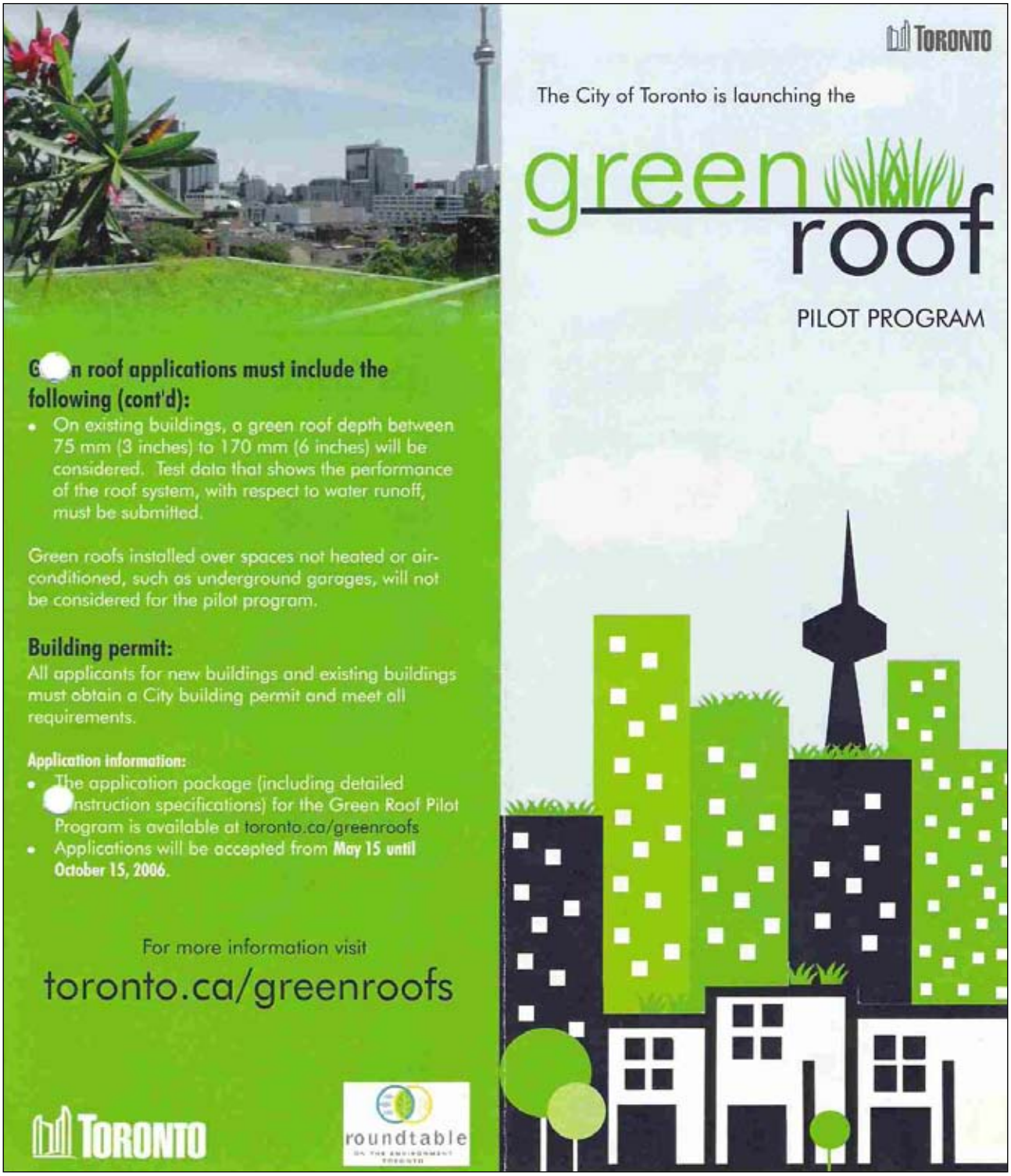
Attachments



Toronto City Council has approved $200,000 for the implementation of a Green Roof Pilot Program. The purpose of the program is to encourage construction of a variety of highly visible green roofs by December 2007.

What is a green roof?

A green roof is a vegetated area that becomes part of the building's roof and includes: a growing medium, a filter layer, a drainage layer, a root resistance layer, a waterproof membrane and vegetation.

Benefits of green roofs:

Green roofs can help: manage stormwater; decrease energy use, especially during peak times; improve air quality; and decrease urban air temperatures (heat island effect). They add lush green spaces to cities, extend the roof-life and can provide a place for local food production.

How much money is available for the construction of a green roof?

The Green Roof Pilot Program will provide a grant of $10 per square metre of eligible green roof area up to a maximum of $20,000.

Who is eligible?

Any private property owner in the City of Toronto is eligible to apply to the Green Roof Pilot Program.

What are the eligibility requirements?

All buildings types are eligible, with the following requirements:

- the building must be heated
- the roof must be above ground level
- it can be both an active (intensive) and a passive (extensive) green roof
- new roof, or a retrofit
- roofs with a maximum slope of 10%

Green roof applications must include the following:

- Continuous coverage of vegetation (over at least 50% of the roof footprint of the building).
- A mix of vegetation as opposed to a monoculture.
- Maximum runoff coefficient of 50%.
- A sustainable organic growing medium; one that replenishes nutrients and retains moisture.
- On new buildings, the green roof must have a depth of 150 mm (6 inches) to allow for a variety of vegetation and help ensure plant survival.

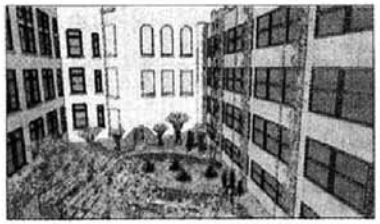
more...

green roofs reduce:

stormwater runoff, roof top temperatures, energy use and air and noise pollution.

Green isn't just a color when it comes to roofs

- Green roofs are coming to the Twin Cities, and landscape architect Peter MacDonagh of the Kestrel Design Group is a leader in the effort.



KESTREL DESIGN GROUP

The green roof planned for Minneapolis City Hall.

By LINDA MACK • lmack@startribune.com

The new Minneapolis library has one. Minneapolis City Hall is getting one. As are the Lunds store at 12th St. and Hennepin Av. S., and the Edgewater and Flour Sack Flats condos.

Green roofs are hot. Or cool, actually. The main green-roof go-to guy in the Twin Cities is landscape architect L. Peter MacDonagh of Kestrel Design Group. Kestrel's roof design for the Green Institute in south Minneapolis won a 2006 award from the international Green Roofs for Healthy Cities organization.

A green roof absorbs rainwater and insulates and cools buildings. That can trim heating and cooling costs and help moderate the urban heat island. Absorbing rainwater reduces the amount of warmed and polluted water running back into the Mississippi River, so cuts the city's treatment costs.

The plantings also double or triple the life of the roof membrane that keeps water from leaking into the building.

Green continues: Planting helps air conditioning keep building cool. **F10** ►

Green isn't just a color when it comes to roofs

◄ **GREEN FROM F1**

Although the technology is new to this area, "there are green roofs in Europe that are 100 years old," said MacDonagh, a softspoken Irishman who teaches at the University of Minnesota.

On three rooftop sections of Cesar Pelli's new library, native and European plants have taken root in 4 inches of soil held down by a rope blanket put down a year ago. Rough Blazing Star, sedum, native asters and goldenrod, purple prairie clover and onion provide a pattern of shorter and taller plantings occasionally punctuated by a prickly pear cactus, which, surprisingly, is native to Minnesota.

MacDonagh said the plantings can absorb 1¼ inches of rainwater in 24 hours. Water that is not absorbed and water from the other roofs on the building flow into cisterns six floors below. It is used in turn to irrigate the plants.

The plants are hardy and will endure drought but do need irrigation during the two years they are getting established, MacDonagh said.

Does the planting make a difference in the heat? Indeed. On a 90-degree day last summer, the temperature on top of the typical black roof hit 170 degrees. On the green roof it measured 92 degrees.

CARLOS GONZALEZ • cgonzalez@startribune.com

Peter MacDonagh of the Kestrel Design Group has become the city's green roof guru. Here he stands among the native and European plants growing on the fifth-floor roof of the new Minneapolis library.

MacDonagh said that the crew testing the air-conditioning system before the building opened in May thought something was wrong.

"It didn't have to work as hard as they expected," he said.

The library's green roofs are visible from other buildings but not from the library itself, except for a small piece that can be seen from the second floor.

Historic City Hall going green

The green roof planned for City Hall's courtyard will be visible from the building's hallways and accessible to the public. The design features winding paths, benches, a pergola, vines growing on tree-like structures and green walls that in some places will be 40 to 50 feet high.

MacDonagh said that real trees get heavier as they grow, which could cause problems, while the vines on the structures will add vegetation without adding significant weight. Green walls, like green roofs, are plantings that help cool the space.

Two cisterns will collect water that will be used to water and mist the plants. The green roof will grow both in shade and in sun.

The Minneapolis Heritage Preservation Commission recently approved the design for the historic building.

"We think that 21st-century technology can enhance the building's historic qualities, just as it did in the renovation of the City Council Chamber," said Jose Cervantes, director of the Municipal Building Commission, a joint city-county body that operates the building.

The $468,000 project, which is being funded by the city, the county and private grants, began with reroofing. The city is trying to lead by example in developing green roofs and saw its own courtyard as a prime opportunity.

(Minneapolis will follow the example of Chicago, which Mayor Richard Daley Jr. has made the nation's Green Roof Capital, beginning with a roof on City Hall.)

MacDonagh said he expects another frontier to be big-box retail, where the roof is the largest surface.

"It's inevitable that one retailer will do it just for the public-relations value," he said. "We're getting inquiries."

Minneapolis architect Tom Hysell, who led the library design team for Architectural Alliance, said, "It won't be too long in the future where green architecture will be a matter of course, just like building a structurally sound building."

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As promised our global warming seminars would offer workable solutions for sustainable landscapes. All three speakers are experienced practitioners and have shown their enthusiasm and commitment through their work.

Jeremy Winer well known AILDM and LCA member and Director of Marsupial Landscape Management and ESD Landscape Contractors will discuss opportunities for designers and contractors in creating sustainable gardens through promoting and commercialising the important role a home garden can play in improving the urban living environment.

Jim Osborne (Environment chair AILA) a prominent Sydney landscape architect runs his practice "Material" with environmentally sustainable outcomes in mind. Jim will give us an insight into how he approaches his projects and the outcomes he hopes to achieve.

Sidonie Carpenter, a Queensland AILDM member, is prominent in the "Greenroof" movement and was recently invited to study "Greenroof" approaches in America. She will share her enthusiasm and knowledge with us as she takes us through some of the "Greenroof" principles which are just as much applicable to a city garage roof as to a large industrial site roof.

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Solar power to shine brightly on green roofs

Solar power is poised for a rapid decline in costs that will make it a mainstream power option in the next few years, according to a new assessment by the Worldwatch Institute in Washington, DC, and the Prometheus Institute in Cambridge, Massachusetts.

This reduction of costs can be expected to energise a joint harness approach to green roofs and photovoltaics.

When he was in Australia last February, **Steven Peck**, President of Green Roofs for Healthy Cities - North America, predicted that Australian solar researchers had the opportunity to become world leaders in solar power and green roof combinations, once cost reductions had been made in photvoltaic technology.

That opportunity appears about to arrive, courtesy of China....

Worldwatch reported on May 22 that global production of solar photovoltaic (PV) cells, which turn sunlight directly into electricity, had risen sixfold since 2000 and grew 41% in 2006 alone. Although grid-connected solar capacity still provided less than 1% of the world's electricity, it increased nearly 50% in 2006, to 5,000 megawatts, propelled by booming markets in Germany and Japan. Spain is likely to join the big leagues in 2007, and the United States soon thereafter.

Worldwatch said: “This growth, while dramatic, has been constrained by a shortage of manufacturing capacity for purified polysilicon, the same material that goes into semiconductor chips. But the situation will be reversed in the next two years as more than a dozen companies in Europe, China, Japan, and the United States bring on unprecedented levels of production capacity. In 2006, for the first time, more than half the world's polysilicon was used to produce solar PV cells.

“Combined with technology advances, the increase in polysilicon supply will bring costs down rapidly - by more than 40% in the next three years, according to Prometheus estimates.

"Solar energy is the world's most plentiful energy resource, and the challenge has been tapping it cost-effectively and efficiently," said **Janet Sawin**, a senior researcher at Worldwatch, who authored the update.

"We are now seeing two major trends that will accelerate the growth of PV: the development of advanced technologies, and the emergence of China as a low-cost producer." She said.

The biggest surprise in 2006, according to Worldwatch, was the dramatic growth in PV production in China. Last year, China passed the United States, which first developed modern solar cell technology at Bell Labs in New Jersey in the 1950s, to become the world's third largest producer of the cells - trailing only Germany and Japan.

China's leading PV manufacturer, Suntech Power, climbed from the world's eighth largest producer in 2005 to fourth in 2006, and PVs have made the company's CEO one of his nation's wealthiest citizens. Experts consulted by Worldwatch believe that China, with its growing need for energy, large work force, and strong industrial base, could drive dramatic reductions in PV prices in the next few years, helping to make solar competitive with conventional power even without subsidies.

"To say that Chinese PV producers plan to expand production rapidly in the year ahead would be an understatement," says **Travis Bradford,** President of the Prometheus Institute. "They have raised billions from international IPOs to build capacity and increase scale with the goal of driving down costs. Four Chinese IPOs are expected to come to market this month alone," he said.

Attachments

Worldwatch said supply shortages had led manufacturers to find ways to use polysilicon more efficiently, and had accelerated introduction of new technologies that did not rely on purified silicon and were inherently less expensive to manufacture. So-called thin film cells could be made from amorphous silicon and other low-cost materials. Companies developing these technologies had recently become the darlings of Silicon Valley venture capitalists.

Although in the past, thin film cells had not been efficient enough to compete with conventional cells, today over a dozen companies - including Miasole, Nanosolar, and Ovonics - were competing to scale up production of low-cost solar modules that could be churned out like rolls of plastic.

"The conventional energy industry will be surprised by how quickly solar PV becomes mainstream - cheap enough to provide carbon-free electricity on rooftops, while also meeting the energy needs of hundreds of millions of poor people who currently lack electricity," Ms Sawin of Worldwatch said.

Note to Editors: To obtain the full Vital Signs Update on solar power, or to interview the author, contact Darcey Rakestraw at drakestraw@worldwatch.org or phone Washington DC 202-452-1992 x 517.

Green roofs can improve photovoltaic efficiency

A rather silly contest occurred in London in April 2007. It was been between the advocates of green roofs and the industry behind photovoltaic panels for electrical power generation from rooftops. Each was competing for roof space priority.

As the photo above from Germany well shows, the two can co-exist on a rooftop. Indeed, the green roof can improve photovoltaic efficiency by reducing the ambient temperature, and the photovoltaic array can help protect the green roof from damage of gusting winds.

Not many people know that photovoltaic arrays have an efficiency drop as ambient temperatures on a rooftop climb steadily during a hot day.

According to an analysis by officers of the Queensland Department of Public Works, at their current state of development photovoltaic arrays are still not economically viable in urban environments. Their figuring runs like this:

"Photovoltaic panels are priced at A$10 per Watt (excluding GST). So a one kilowatt panel will have a purchase cost of around AU$10,000. With installation, the cost comes up to around $14,000. (For comparison, a coal-fired power station produces electricity at a cost of around $1,500 per kilowatt). Nevertheless photovoltaic panels do have a place in remote locations where the cost of providing or upgrading the mains electricity grid can be substantial.

"Practicability is a further issue. The same one kilowatt panel discussed above will cover an area of 12 square meters, and should have a northerly orientation for optimum performance. The one kilowatt output is a maximum rating that varies with the orientation of the panel relative to the sun, the amount of cloud cover, and the temperature (with output dropping off as the temperature climbs above 25°C.

"With commercial office buildings requiring electricity in the range of megawatts, a photovoltaic array would have to extend over an area of several thousand square meters in order to provide, say, 50% percent of such a building's power requirements during daylight hours".

The Queensland Department of Public Works' has been engaged in research involving the use of photovoltaic panels and interactive inverters that enable surplus electricity for the solar panels to be fed into the main electricity grid.

The Department has designed, constructed and installed three prototype systems that are currently undergoing testing. A full report will be published soon in **Urban Agriculture Online** (see www.urbanag.info).

Brisbane votes for urban agriculture and green roofs

Brisbane, in Queensland, Australia, is the first city in the world to include both urban agriculture and green roofs in an action plan to meet predicted global climate change challenges.

This is expected to develop the City of Brisbane as a centre of excellence in both technologies.

The Brisbane City Council (BCC) this week adopted, unanimously, an action plan based on commissioned reports and its own sustainability studies over the last two years.

Major parts of the action plan are aimed at reducing Brisbane's use of energy derived from fossil fuels and encouragement of more efficient use of water. But sensible, practical ways to mesh these aims with creating a new style of built-environment attracted enthusiastic votes for:

- Urban agriculture for greater food security and reduced cost of living that includes aquaculture and aquaponics.
- Green roofs that provide a built-environment attuned to good climate change responses rather than being part of the problem.

Both urban agriculture and green roof developments in their widest context were foreseen by BCC councilors as important for improving both living conditions for people during climate change, and to maintain and develop businesses and employment.

Brisbane City Council comprises 25 councilors led by Liberal Party Lord Mayor, **Cr Campbell Newman.** But he was well supported in the climate change action plan by Labor Party Deputy Mayor, **Cr David Hinchliffe**, plus all other councilors. BCC is the largest municipal government in Australia. As such it provides considerable leadership to all municipal governments in Australia.

Thus, BCC's adoption of urban agriculture and green roof technologies in its climate change action plan is expected to trigger a cascade of similar interest by Australia's municipal governments.

In August 2006 Brisbane City Council appointed a Climate Change and Energy Taskforce to ensure that Brisbane is adequately prepared to respond to and address the challenges of climate change, increasing energy consumption, rising petrol prices and peak oil.

On 12 March 2007, the BCC's Climate Change and Energy Taskforce, led by **Professor Ian Lowe,** presented its independent report titled **'A Call For Action'** to Council. The Taskforce considered comments from an earlier discussion forum last December. Councilors were well-back grounded on urban agriculture and green roofs (BCC councilors and staff were a major part of the **Green Roofs for Australia** conference on February 22 and 23, 2007).

A debate on Monday, 30 April, has produced an action plan the BCC will take to its ratepayers for one month of comment before adoption in its final form, probably by June 30, 2007.

Further information: Geoff Wilson, President, Green Roofs for Healthy Australian Cities, and President, Urban Agriculture Network Australia. Phone: +61 7 3411 4524 or +61 (0)412 622 779. Email: Geoff @nettworx.info. Address: 32 David Rd. Holland Park, Queensland 4121, Australia

May 1, 2007.

Sidonie brings green roof skills to Australia

Sidonie Carpenter, pictured, is Vice-President of Green Roofs for Healthy Australian Cities. She has returned to Australia following a study visit to North America to collect latest information on green roofs and walls. Sidonie is available for interviews and talks on green roof developments in North America that are relevant to Australia's nascent green roof industry.

Sidonie's study fellowship was awarded by the Melbourne-based International Specialised Skills Institute, funded by the Pratt Foundation, and supported by Brisbane Architect, Geoffrey Pie, Landscape Logic, Multiplex Australia, Mirvac Australia, The Plant Specialists and landscape architect Richard Jones.

She runs her own Brisbane-based business, Sidonie Carpenter Landscape Design and Horticulture. Sidonie studied for an arts degree at the University of Queensland (majoring in architecture and town planning). She also holds a graduate diploma in landscape architecture from Queensland University of Technology, and is a member of the Australian Institute of Landscape Design and Managers.

While in North America visiting leading green roof cities of Canada and the United States, Sidonie attended (April 29 to May 2) the annual Green Roof conference of Green Roofs for Healthy Cities - North America in Minneapolis, where she also attend two, one-day courses on green roof design and construction.

She represented Australia at a meeting of the World Green Roof Infrastructure Network (WGRIN) in Minneapolis on 30 April. This newly-formed organisation (2006) now has 15 national members in Europe, North America and Australasia. It expects to help bring green roof and green wall climate change responses to many other areas, especially to Asia.