Natural Economy
Northwest

Roof greening in Liverpool

Commissioned from The Mersey Forest by Natural Economy Northwest

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PREFACE

This is one in a series of reports produced between 2007 and 2009 within the Natural Economy Northwest (NENW) Programme. NENW is a regional partnership programme led by Natural England, the Northwest Regional Development Agency and SITA Trust on behalf of a wide range of economic and environmental partners. The main focus is to deliver priority action 113 in the Regional Economic Strategy, to optimise the natural environment's contribution to the regional economy and quality of life.

The Programme also includes the Enriching Nature SITA Trust biodiversity programme and the aspirations of Natural England and other environmental and economic partners to mainstream the natural environment within sustainable economic development. Key work areas within the programme are to:

- increase awareness of the value of the natural economy,
- commission and disseminate research to promote and facilitate delivery,
- provide direction to promote effective use of limited financial resources,
- contribute to the development and delivery of regional and sub-regional strategies,
- facilitate natural economy project development and encourage project delivery,
- promote and facilitate Green Infrastructure and Natural Tourism especially through the Sub-Regional Economic Partnerships and the Tourist Boards,
- encourage strategic investment in natural economy projects, and
- to facilitate training, skills innovation and advice to business.

In the partnership between NENW and SITA Trust, SITA Trust Enriching Nature funded projects were assessed for their delivery of economic benefits. Those that scored highest were given enhanced funding to develop the project further, to optimise the economic benefits and to inform further development of the natural economy of the Northwest. This was one such project receiving enhanced funding through the NENW programme and the report was prepared by Nick Roche at The Mersey Forest using the Toxteth TV green roof as a case study for considering the potential for green roof development in Liverpool. The report reviews the case for green roofs, while attempting to dispel misconceptions that result in resistance to their installation. The report then looks at the policy environment internationally, nationally and more locally before moving on to assess the potential for green roofs in central Liverpool.

The collaboration with SITA Trust for linking the Enriching Nature Programme with this pilot in the Northwest, to position biodiversity projects for their contribution to socio-economic frameworks, has been very much appreciated. Biodiversity projects within the overall approach of Green Infrastructure not only contribute directly to economic benefits but also underpin sustainable economic futures through investment in ecosystem services.

This work along with other NENW information and publications is on our website – www.naturaleconomynorthwest.co.uk. You can contact us through our website. We are interested in the ways that this report has been of use to you so that we can take into account in the further development of the programme.

This report has been commissioned by Natural Economy Northwest in the delivery of its aims, outputs and outcomes and it should not be assumed that it represents the policy of the funders – Northwest Development Agency, Natural England and SITA Trust.

Dr Will Williams

Programme Director
Natural Economy Northwest

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Executive Summary

Green roofs, in all situations, can provide a wide range of benefits and in many situations would hold up well in an analysis of costs against benefits.

Benefits range from improving building insulation (winter and summer) and reducing storm water runoff, to contributing to a reduced 'heat-island' effect and improving city-centre biodiversity. By using extensive or biodiverse green roof systems it is possible to keep costs down in retro-fit installation and to a negligible level in new-build projects.

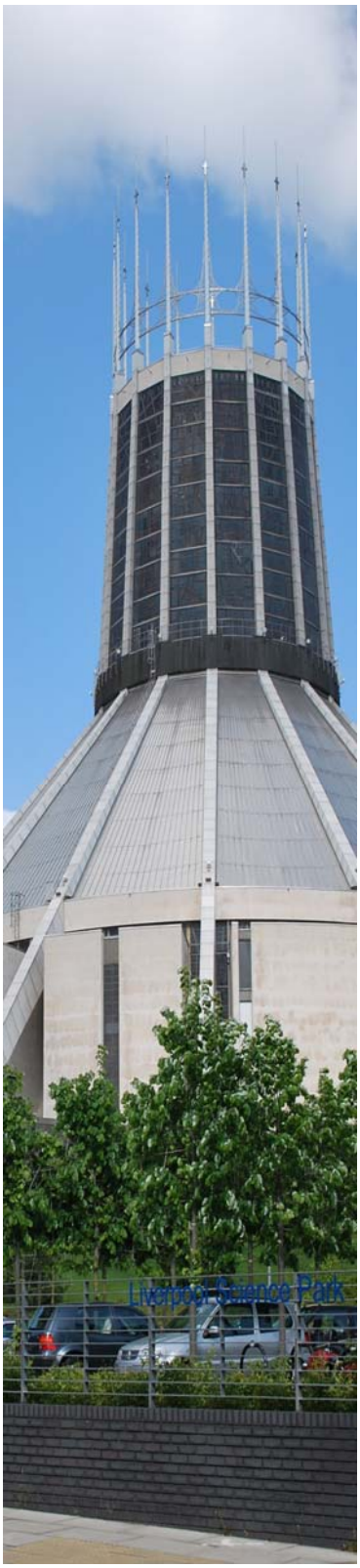
Although there are few explicit drivers to installing green roofs in British cities, a number of national and regional policies, within their green infrastructure guidelines, implicitly support the use of such technologies. This is especially so when considering sustainable city living and Sustainable Drainage Systems (SUDS). In countries and cities where policy requires that green roofing is considered in building design (for example Germany), then significant areas of green roof have been installed (more than 100,000m^2 in Stuttgart).

Happily there are several green roofs in Liverpool, but the City is still relatively new to the idea, the existing roofs are well kept secrets, but there is enormous potential, especially given the degree of inner-city regeneration that is planned over the next few years. The key to ensuring that green roofs are used as a tool to meet government and local objectives hinges on the way that development control and building regulations are interpreted within the framework of national and regional development and promotion of the benefits of green roofs to developers and designers.

There are a number of actions that should be taken to embed roof greening in project design and building in the City, among which would include: an awareness raising campaign to inform the sceptics and the uninitiated; the establishment of a green roof network that would include champions promoting their use among developers, builders, architects, project managers and in local government, a green roof map of the city would enable people to see where they had already been installed, creating confidence that this is actually mainstream and economically a sound investment. Finally, as a further catalyst, funding should be found to help organisations and project managers install green roofs (specifically biodiverse roofs) that can then be used to demonstrate the benefits to others.

Roof Greening in Liverpool

Regeneration in Liverpool has been driven forward over the last decade by substantial amounts of money invested to reduce urban decline. This development has gone ahead in times that have seen both economic and climatic turmoil provide the context in which developers, project and estate managers, planners and architects have had to design and build infrastructure for the next decades. Economic, climate and environmental uncertainty has lead national and local government to place sustainability at the heart of development policies in an effort to ensure that infrastructure is better adapted to meet the challenges of the future.



Sustainability has risen in importance through the ranks of policy issues to dominate many current agendas, but what is sustainability? A classic and simple definition comes from the Brundtland Commission which met from 1983[1], in which sustainable development was defined as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs". There are of course many facets of the outworking of this: from developing renewable energy technologies to constructing energy efficient buildings; from growing renewable natural resources to recycling materials; from reducing green house gas emissions to increasing carbon sequestration; from increasing biodiversity to improving public health and much more.

The range of different issues ensures that only a mix of solutions will offer society a future better adapted to predicted and unknown changes. It will involve buildings constructed from materials offering improved environmental benefits, connected by more efficient transport systems, within a setting that is both better suited to changing climate and able to offer healthier life styles. The different aspects are heavily interrelated and even inseparable from one another with no easy or quick-fix solution. That roof greening should be an issue for consideration comes from the fact that it is one of the tools within the toolkit for creating a better working environment, improving carbon footprints of buildings, reducing down-stream management costs and very importantly, increasing city-centre biodiversity. The need for change becoming apparent from the kind of facts provided by a key-note speaker at a recent green roof conference: 600 Londoners died in 2003 from the effects of the heat wave; if every flat roof in London were given over to roof greening, then enough water to fill 35 Olympic size pools would be held back from the waste water system; in London there has been a loss of back gardens to infill development, paving and decking, equivalent to Hyde Park 22 times over[2]; the Government has set a target of 60% of housing and industrial development to be on brownfield sites[3].

Roof greening offers partial solutions to a number of issues and it is the intention of this report to look at the potential in the City of Liverpool, the planning context, costs and benefits and some guidance for interested developers and project managers. The report cannot be a one-stop-shop for green roofs as there are not sufficient resources to achieve that and

[1] Report of the World Commission on Environment and Development: Our Common Future. General Assembly Resolution 42/187, 11 December 1987.
[2] Key note address, Richard Blakeway, Advisor to the Mayor of London, World Green Roof Congress, London, 2008
[3] Local Wildlife Sites – Brownfield / Urban. Lincolnshire Biodiversity Partnership. September 2007

there are also many very good alternative resources out there[4] [5] [6], but it is hoped that it will provide enough information to guide prospective 'roof greeners' or policy makers with an interest in green roofs to key issues.

Introduction

The 'Roof Greening in Liverpool Project'

The Roof Greening in Liverpool project, supported by The Mersey Forest, springs out of and seeks to build on the successes of similar work undertaken in Manchester funded by the Natural Economy Northwest Programme and implemented by the Greater Manchester Biodiversity Project[7].

The aim is to investigate the potential for roof greening in Liverpool, focussing on, in the first instance, the 'Liverpool Knowledge Quarter', an area with over £600m of new development planned for the next 15 years. The core area of the Quarter stretches from the City's Anglican Cathedral to the south, through to the Liverpool University Hospital and Liverpool School of Tropical Medicine at its northern fringe, it also reaches out to and includes Liverpool John Moores University's City campus on Byrom Street. However, the geographical boundary of the Knowledge Quarter will not limit the scope of the Project and any buildings or projects that fit within the broad aims should be included in the consideration of potential.

Photo 1: Liverpool Knowledge Quarter, towards the cathedrals

Photo 2: Liverpool Knowledge Quarter, towards Liverpool University

This report, the outcome of work undertaken between December 2008 and April 2009, provides:

- An overview of roof greening benefits and costs;
- A review of how roof greening can help to deliver a range of Green Infrastructure benefits;
- Issues that create a resistance to installation of green roofs;
- A review of the policy environment;
- An estimate of the potential for roof greening in Liverpool, particularly in the Liverpool Knowledge Quarter;
- Potential projects.
- Case study of an example in Liverpool;
- Recommendations for the next phase of work;

It must be emphasised that as this report is primarily a review, it draws heavily on available literature (often quoting authoritative sources), organisations and web sites that offer advice and recommendations. The intention is that readers refer to those sources for the detail that is only indicated or summarised.

What is a Green Roof?

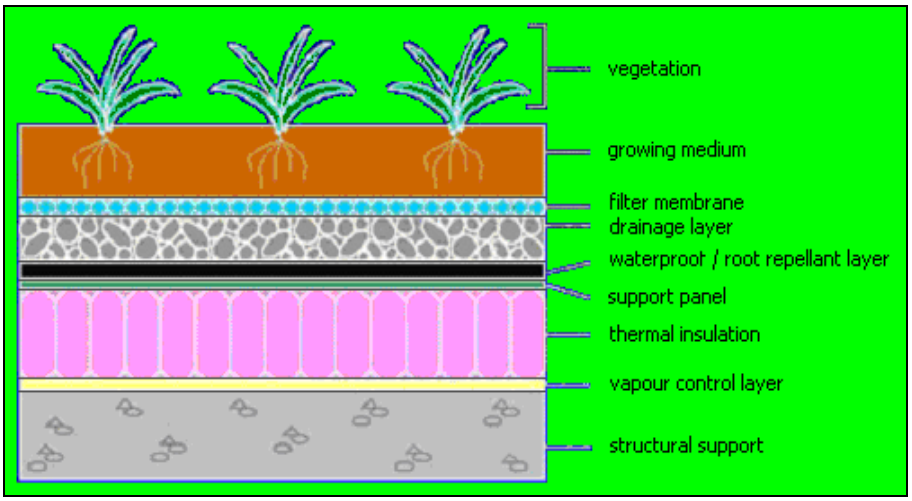
A green roof system is simply a roof space of any size, at any height, that has been intentionally covered, or partly covered, with a layer of substrate and vegetation. It is an extension of the existing roof which involves a high quality water-proofing and root repellent system, a

[4] Roof Greening in Greater Manchester; A Review. D Richardson, G Jones.
[5] The Green Roof Centre, Sheffield
[6] BUILDING GREEN*er*: Guidance on the use of green roofs, green walls and complementary features on buildings. J Newton, D Gedge, P early, S Wilson. CIRIA. C644, London 2007.
[7] Roof Greening in Greater Manchester; A Review. D Richardson, G Jones.

drainage system, filter cloth, a lightweight growing medium and plants. This definition includes systems that have a low-fertility substrate and may or may not include thermal insulation, but may be left to colonise naturally.

There is a distinction from aerial gardens that are installed for purely aesthetic reasons and will involve largely non-native and 'domesticated' vegetation that is limited to pots or discrete beds.

Figure 1: Principle green roof technology components



Source: National Research Council, Institute for Research and Construction, Canada

Photo 3: A green roof, Okowerk Environment Centre, Berlin - 1890

Different publications talk of extensive and intensive green roofs, biodiverse roofs, meadow roofs, turf roofs, eco-roofs, living roofs, rubble roofs, brown roofs, all of which reflect either origin or intention, but in this document are considered to be covered by the term green roof. It is important to note that the term green roof can therefore be misleading as some of the systems result in appearances that are definitely not green. The term is not ideal and can create an expectation that may remain unmet. No effort is made to provide an alternative name as this will do more than to add to the list of existing names.

Finally, this report focuses on systems that are low fertility or 'extensive' systems (excluding *Sedum sp.* roofs as there is an abundance of information on *Sedum* roofs on the web) that require little or no maintenance (such as irrigation) and are biodiverse in nature. It is considered that an important benefit should be that the roof is low maintenance and contributes to city centre biodiversity and it is fortunate that the two are highly compatible.

The Case for Green Roofs

The question "why a green roof?" is pertinent, as it would probably be true to say that unless someone has developed an interest (often for a particular reason such as biodiversity), then there is a general perception that green roofs are a little outlandish[8]. In response, the justification for considering a green roof will lie somewhere within the following direct benefits:

Economic benefits

- Cost savings through protection of the roof fabric

[8] Planting Green Roofs and Living Walls. Nigel Dunnett, Noël Kingsbury. Timber Press 2004.

- Improved insulation reducing building heating and cooling costs
- Improved waste water management
- Improved labour productivity
- Improved corporate image

Environmental benefits

- Enhanced biodiversity
- Storm water attenuation

Social benefits

- Reduced urban heat-island effect
- Sound insulation
- Improved filtration of airborne particulates
- Improved labour welfare
- Improved amenity space and aesthetics
- Potential for food production

It is important to note that many of the benefits are overlapping and should not really be considered in isolation. However, in this report they are, in general, discussed as discrete issues.

The Economic Benefits

i. Cost savings through protection of the roof fabric

If the roof fabric is protected from damage from UV light, diurnal changes in temperature and excessive rainfall events, then there can be an increase in life expectancy of up to two to three times. A roof membrane underlying a green roof in Kensington, London is still in excellent condition 60 years after installation[9]. Analysis of this saving has been made by a number of organisations and an example is reproduced below:

Table 1: Case study of a 1,000m^2 of roof, Bridgewater

Cost Item	Exposed	Extensive	Biodiverse
Capital (m^2)	£47,000	£93,000	£79,000
Maintenance (yearly)	£150	£600	£150
Repair (yearly)	£0	£2500	£1250
Energy Saving	£0	£5.20	£5.20
NPV (6% discount rate)	-£49,160	-£21,268	£7,453
Ranking	3	2	1
TWLC (non-discounted cash flow)	£51,500	-£132,000	-£175,800
Ranking	3	2	1
AWLC	£1,716	£2,640	-£3,516
Ranking	3	2	1

NPV is net present value using a 6% discount rate in a discounted cash flow; a negative number indicates cost rather than value. The highest positive number indicates best option.
TWLC is total whole life cost using a non-discounted cash flow. A negative number indicates a net inflow of cash, highest negative number is best option.
AWLC is the TWLC divided by the life of the product. It is in effect the annualised cost of the product. A negative number indicates a net annual inflow of cash, highest negative number is best option.

Source: The Solution Organisation, for Sarnafil ltd.

ii. Improved insulation reducing building heating and cooling costs

Much is made of the insulating effect of green roofs and the following table demonstrates why it is important, where the summer temperatures are significantly lowered with potential savings in air conditioning costs for commercial buildings.

[9] The Green Roof Pocket Guide. The Green Roof Forum

Table 2: Comparison of waterproof membrane temperatures

Season	Mean air temperature	Temperature under standard roof membrane	Temperature under green roof Membrane
Winter	0°C	0.2°C	4.7°C
Summer	18.4°C	32°C	17.1°C

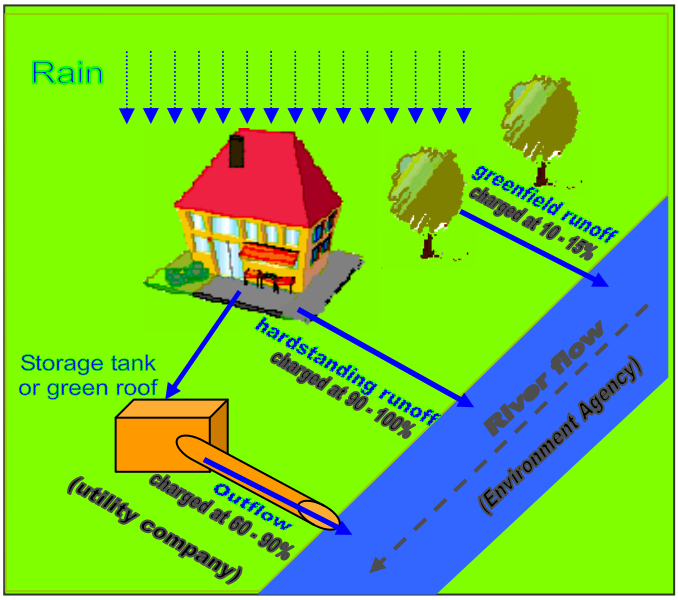
Source: CIRIA, with data provided by Nottingham Trent University

Winter savings are possible, but buildings require additional wall and window insulation to ensure that heating losses are minimised from other sources. Staff at the Unicorn Grocery in Manchester report more comfortable winter working conditions (warmer) after the green roof and associated thermal insulation was installed.

iii. Improved waste water management

The literature makes much of the effect that green roofs (and green infrastructure generally) can have on rainfall runoff—covered in more detail in the environmental section—which can lead to savings in charges that utility companies make:

Figure 2: Waste water management



An organisation in Liverpool was able to obtain a waste water rebate of about 30% off its annual bill from the utility company (about £300 off an annual bill of £1,300)[10].

iv. Improved labour productivity

Aerial views are often neglected in city planning, yet personal experience suggests that a 'grey' roofscape, such as illustrated in the photograph of a Liverpool roofscape (photo 4), can be rather dispiriting and it does not take much to imagine that such a 'scape', broken up with greenery and some colour might improve the sense of wellbeing for people living and working in the city centre.

A London docklands office in Canary Wharf with such an outlook is shown in photo 5. The city centre view is broken up by looking across a simple *Sedum sp* roof (photo 5), that in this photo is in its summer flowering phase and makes a big difference to what would otherwise be a very built-up vista.

Photo 4: A 'grey' roofscape across Liverpool rooftops towards the River Mersey.

Photo 5: A view onto a *Sedum* roof in Canary Wharf, London

[10] Pers. comm. Toxteth TV Project, Windsor Street, Toxteth, Liverpool.

v. Improved corporate image

Corporate image benefits from green credentials and although there are many ways in which organisations can demonstrate their commitment to the green agenda, investment in green infrastructure is an obvious route to take. There are numerous examples, but international literature reviews have highlighted use by the Ford Motor Company of a green roof together with its advertising hoardings[11]. The photographs were included in an 8-page advertisement in which it was stated that "*This is not environmental philanthropy. It's sound business.*"

Photo 6: A view onto a green roof built by the Ford Motor Company in Dearborn, Michigan

Green roofs can be a highly visible symbol of environmental policies and many commercial companies, public bodies and local government authorities have found them to be an effective way to point to other green initiatives they may be engaging in that are less visible, as well as benefitting from the associated cost savings on heating / airconditioning and waste water management.

The Environmental Benefits

vi. Enhanced biodiversity

Enhanced biodiversity in urban areas is part of a wider strategy to protect established habitats, create a network of new habitats in the face of loss of brownfield sites, establish wildlife corridors and provide space for species adaptation. Brownfield sites are particularly important because invertebrates frequently prosper in habitats where plants are stressed—an unstressed plant will divert nutrients into developing chemical defences to insect attack, whereas a stressed plant is unlikely to do so. Plants in a stressed situation will also produce more seed and nectar to encourage fertilisation and seed production to ensure that the genetic line is continued, which again encourages invertebrates to thrive.

Photo 7: Laban Dance Centre, London (brown/biodiverse) roof.

Green roofs are an important part of compensating for lost brownfield sites. They are characterised by being seasonally dry with shallow, often infertile soils which is fundamental in plant ecology to support a large variety of species. The low fertility precludes the more aggressive and nutrient demanding species that dominate in more fertile soils, allowing the wider range of species to flourish[12]. Associated with the plant species there will be invertebrates and animals, especially birds, some of which are becoming rare in the urban environment as other similar (often brownfield) habitats are lost—the black redstart being a well-known example[13]:

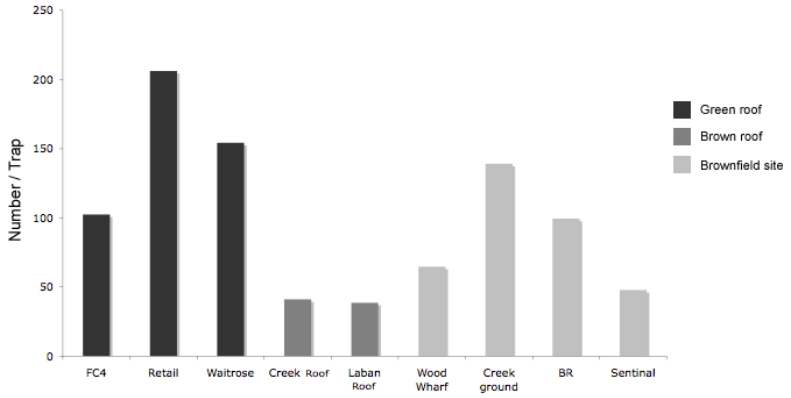
There is much in the literature of the importance of urban habitats and of the role of green roofs in maintaining biodiversity and habitat networks. The following diagram is one such representation of the ecological importance:

[11] Green Roof Policies: Tools for Encouraging Sustainable Design. Goya Ngan, December 2004

[12] Planting Green Roofs and Living Walls. Nigel Dunnett, Noël Kingsbury. Timber Press 2004.

[13] Roof Greening in Greater Manchester; A Review. D Richardson, G Jones. 2008

Figure 3: The mean number of invertebrates collected in insect traps (2004).



Source: Urban Habitats, volume four, December 2006[14]

Roofs that will be heavily accessed for amenity or welfare purposes will be more disturbed and less valuable as habitats (unless carefully zoned, such as the Unicorn roof in Manchester[15]) and it will be those that are inaccessible that will have the most value. However, it is important to note that all green roofs will have some biodiversity gain and are certainly of far greater value than a roof with no structures in place.

vii. Storm water attenuation

Traditional drainage is designed to move rainwater, especially storm water, away from the point at which it has fallen to a watercourse as rapidly as possible. This approach has a number of harmful effects[16]:

- Run-off from hard paving and roofing can cause sudden rises in water levels and flow rates in downstream drains and watercourses;
- Run-off can contain contaminants such as oil, organic matter and toxic metals. The levels are generally quite low, but cumulatively they can result in poor water quality in rivers and groundwater which will affect biodiversity, amenity value and potential water abstraction;
- By diverting rainfall into drains, water no longer soaks into the ground, depleting ground water and reducing stream flows in dry weather.

The Environment Agency, with the responsibility "to make the environment cleaner and healthier", aims, among many other key objectives, to manage the risk of flooding using Sustainable Drainage Systems (SUDS) as a key technique to control the quantity and quality of water run-off. The following diagrams illustrate why green infrastructure and green roofs are an important part of a well-designed system[17]:

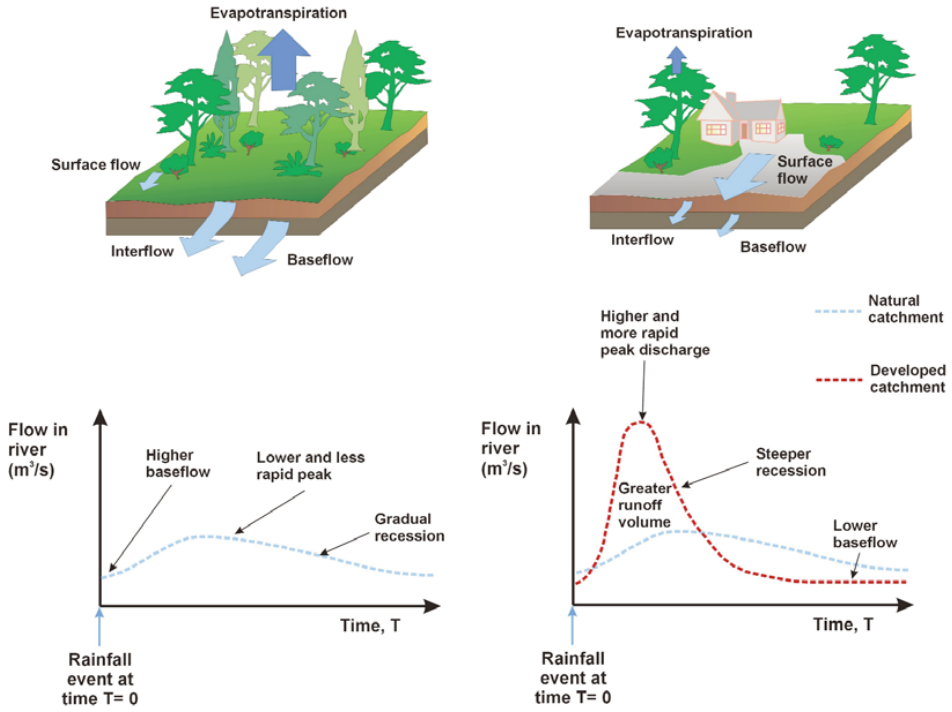
[14] Rare Invertebrates Colonizing Green Roofs in London. Gyongyver Kadas. Royal Holloway University of London. Urban Habitats, volume four, December 2006.

[15] Roof Greening in Greater Manchester; A Review. D Richardson, G Jones. 2008

[16] Environment Agency web-site: http://www.environment-agency.gov.uk/business/sectors/36998.aspx

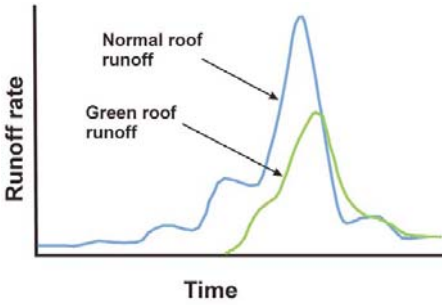
[17] BUILDING GREEN*er*: Guidance on the use of green roofs, green walls and complementary features on buildings. J Newton, D Gedge, P early, S Wilson. CIRIA. C644, London 2007.

Figure 5 Impact of development on storm water runoff



The following diagram demonstrates that green roofs have a very similar effect on runoff flows:

Figure 6 Example comparison of runoff from green and conventional roofs



Source: BUILDING GREENer: Guidance on the use of green roofs, green walls and complementary features on buildings

Green roofs can act as natural storage for water after rainfall events. In situations where drains are overstretched during storm events, then any amelioration will spread out the impact, both in terms of retaining water within the reservoir of the substrate and vegetation, but also in delaying release into the drainage system. The filtration effect through vegetation and substrate will also improve the quality of run-off which is an issue for the wider river catchments that already suffer contamination from particulates, hydrocarbons, heavy metals, road salts, animal waste (dog faeces, guano) and pesticides (used to treat unwanted vegetation).

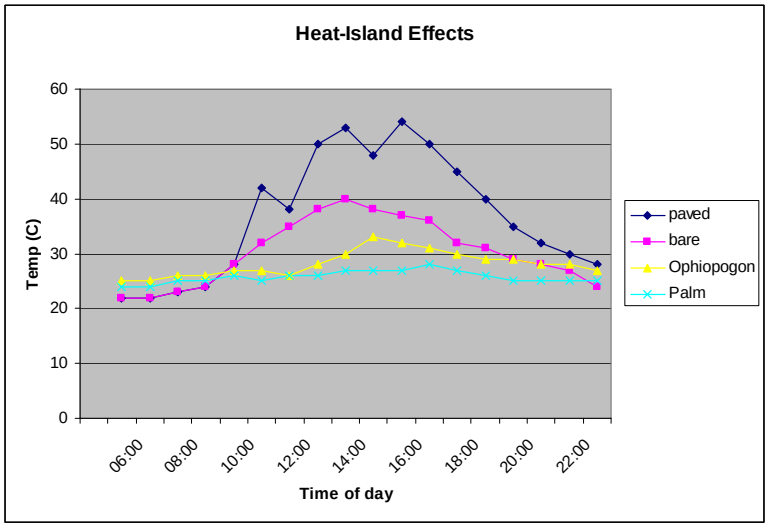
The Social Benefits

viii. Reduced urban heat-island effect

Urban heat-island is a term that denotes an area significantly warmer than surrounding rural areas. The temperature difference generally being larger at night than during the day and larger in winter than in summer and is most apparent when the winds are light. Different surfaces can affect the temperatures and vegetation will significantly reduce the variation as the following diagram, which is a comparison

between a paved surface, a bare area, an area under a palm species (*Raphis sp.*) and an area under *Ophiopogon sp.* (a plant forming an evergreen turf-like mat)[18], shows:

Figure 4: Surface temperatures under different vegetation.



Source: Urban Habitats, volume four, December 2006

Research has shown that the death rate for cardiovascular conditions, such as heart attacks and strokes, rises during heat waves. Research has also now shown that high summer temperatures have a clear impact on rates of admission to hospital for elderly patients with breathing problems and admission rates for respiratory causes among the 75+ age group were more than twice the admission rate for all ages[19]. This suggests that during periods of high temperature, many deaths from causes such as heart attack and stroke occur rapidly before patients can be admitted to hospital. By contrast, respiratory problems tend to peak later, up to three weeks after a high temperature event, giving patients more chance to receive medical attention in hospital.

It is now well known that green infrastructure mitigates the differences in temperatures as shown in the above diagram and green roofs play a useful part in controlling the urban heat-island effect. Clearly if heat-wave and summer time temperatures can be reduced, then this will have an impact on death rates and hospital admissions as well as ameliorating the climate for all city dwellers and visitors. According to research by the Hadley Centre, by 2040 more than half of summers will be warmer than 2003 and by 2100 summer temperatures similar to 2003 will be classed as cool. Green infrastructure, with green roofs playing a potentially significant role, can help mitigate climate change by reducing energy demand for cooling buildings. Modelling work in Greater Manchester suggested that if the city increases green cover by 10%, it will be possible to keep surface temperatures at current levels despite climate change[20].

ix. Sound insulation

[18] Planting Green Roofs and Living Walls. Nigel Dunnett, Noël Kingsbury. Timber Press 2004.

[19] High Temperature and Hospitalizations for Cardiovascular and Respiratory Causes in 12 European Cities. Michelozzi, P., Accetta, G., De Sario, M. *et al.* (2009). *American Journal of Respiratory and Critical Care Medicine.* 179: 383-389.

[20] http://www.sustainablecities.org.uk/greeninfrastructure/heat-island

Green roofs, through their insulating properties, can reduce sound by between 40-50 decibels, depending on the type of green roof[21]. Green roofs absorb sound through the vegetation and substrate, mitigating outside noise as well as interior noise. Green roofs can therefore be a useful way to block noise from adjacent roads and under busy flight paths.

x. Improved filtration of airborne particulates
Vegetation, and in particular urban trees, have long been shown to absorb particulate matter and improve air quality. Researchers in Toronto have used an urban forestry model to estimate the equivalent air pollution mitigation potential of green roofs and found that green roofs, when combined with grasses, shrubs and trees, could play a significant role[22]. If only 10% of Chicago's roofs (6,540 ha) were greened, 17,400 tons of NO_2 per year would be removed, resulting in city-wide public health benefits from reduced air pollution of between $29.2 million and $111 million annually[23].

xi. Improved labour welfare
The possibility for staff to access green space close-by the work place during breaks when the weather is good is considered an important part of health and wellbeing at work[24]. Two examples of roofs installed in Manchester are well used by staff for recreational purposes and as a venue for summer-time meetings and corporate events. (Photos 8 and 9).

xii. Improved amenity space and aesthetics
There is little published research on the social or health benefits of green roofs, as most of the research is based on the effects of contact with green space and nature—improved health, well-being, socialisation and an improved sense of community. It is by extension that the benefits can be applied to green roofs and where green roofs have been put on hospitals, high-rise appartments, commercial buildings to provide amenity space and safe play areas, they are able to partly replace ground-level greenspace when it is not otherwise available[25] (photo 10).

xiii. Potential for food production
Green roofs have the potential to grow food, and have been used by community groups looking for additional garden space, as well as restaurants, hotels and hospitals who have used roofs to provide fresh herbs and salad. Waterfront Hotel in Vancouver, Canada (photo 11) is an example of a hotel where the garden, covering 195m^2, provides all the hotel's need for herbs in addition to being an amenity space for guests, reduces food costs by $30,000 each year, insulates the building and reduces rain water run off[26].

An opportunity lies in the use of roof space on buildings, such as hospitals, for food production, both to reduce expenditure on fresh

Photo 8: Purpose built roof, Unicorn Grocery, Manchester

Photo 9: Purpose built roof, MERCI, Ancoats, Manchester

Photo 10: Chicago City Hall.

Photo 11: A green roof on the Waterfront Hotel in Vancouver, Canada.

[21] cited in Green Roof Policy Development Workshop, GRHC, 2006. Peck et al 1999,
[22] Estimates of air pollution mitigation with green plants and green roofs using the UFORE model A. a. I. R. Group, Environment Canada. Bass, B. and B. A. Currie (2006).
[23] Optimization of Green Roofs for Air Pollution Mitigation. Third Annual Greening Rooftops for Sustainable Communities Conference. Washington, DC, Green Roofs for Healthy Cities. Clark, C., B. Talbot, et al. (2001).
[24] Green roof toolkit. The Environment Agency. http://www.environment-agency.gov.uk/business/sectors/91967.aspx
[25] The scaling of green space coverage in European cities. Biology Letters. Fuller, R. A. and Gaston, K.J. (2009). doi:10.1098/rsbl.2009.0010
[26] Green Roofs for Healthy Cities. About Green Roofs. http://www.greenroofs.org

food, but also to provide amenity space for staff and patients and to offer theraputic activities to convalescing patients.

Resistance to Green Roofs

That resistance exists is evident from the fact that many cities have very low levels of roof greening, and those few cities that have higher coverage (such as Linz, Austria), do so because of significant inducement. Where, therefore, does the resistance to green roofs come from? Some of the most common responses to proposing a green roof installation might come from one or all of the following:

- Too expensive to install;
- Slope of the roof too great;
- Planning permissions difficult to obtain;
- Creates insurance headaches;
- Maintenance costs too high;
- A liability – roof leaks, fire risk;
- Tenants will not want the responsibility;
- Depending on the kind of roof installed, the aesthetic impact will be disappointing;
- For developers, no return on the investment;

This perception is due, in part, to a lack of understanding about green roofs and their installation, in part to bad experiences through inappropriate installation, in part to the impression of 'exclusivity' created by 'high-tech' companies that have developed a niche for specialist 'intensive' technologies and in part to genuine concerns about the efficacy of green roofs.

The intention in this section is to review the facts and the perceptions, look at some of the costs and benefits in more detail in an effort to dispel misconceptions and provide information on the true costs in order that, in the event of a green roof being considered at the design stage, a balanced and informed decision can be made about inclusion.

Tackling the Concerns

i. Expensive Installation Costs

Capital costs will be more expensive than for a standard roof. The installation of an 'extensive' green roof is generally considered to double the cost of waterproofing and insulating a roof, as prices can vary from £20-70 per m² exclusive of insulation and waterproofing. The lowest costing green roofs use secondary aggregates from the construction process which are sown with seed mixes or allowed to colonise naturally[27]. One source suggests that £80 / m² for an 'extensive' roof and £140 / m² for an 'intensive' roof are a reasonable estimate[28]. Informally, the Manchester project talked of being able to install a green roof of 30 – 35 m² for as little as £7-8,000 (exclusive of waterproof membranes).

However, it is important that the context of the roof is taken into consideration: Is the roof retrofit or new development; what is the final use of the roof (types of access); what were the original design specifications of the roof structure (light-weight or load-bearing); what span is being considered; is there a significant pitch to the roof?

[27] The Green Roof Pocket Guide. The Green Roof Forum

[28] Roof Greening in Greater Manchester; A Review. D Richardson, G Jones. 2008 *(original source: the green roof centre)*

The costing for any single roofing project will lie somewhere along a continuum. As pitch, span, access and visual amenity requirements increase, so will the costs.

Load bearing is an important element in assessing costs and there is extensive literature on loading, so the intention is not to provide a technical overview, but only to give a snapshot of the magnitude of the issue by making comparisons with other loadings:

Gravel Surface 90 - 150 kg/m2
Paving Slabs 160 - 220 kg/m2
Vehicle Surfacing from 500 kg/m2
Extensive green roof 60 - 150 kg/m2
Intensive green roof 200 - 500 kg/m2

Modern, light-weight green roof systems weighing between 60-150kg m² fall well within the loading capacity of modern building regulations, but when soil depths, water-holding capacity and vegetation is increased, for whatever reason, then there will be significant structural implications.

Photo 12: A 'living wall' in Paris – a Patrick Blanc wall, Musee du Quai Branley .

ii. Slope of the Roof too Great

In general there is a perception that slope can be a problem, but there are technologies that exist that can put a living 'roof' onto vertical walls—green walls, or living walls is not a technology that is discussed here, but is often included in green roof literature.

However, the recommendation is that 17% (9.5º) is the maximum before specialist construction and substrates have to kick in. At slopes in excess of this, the membranes and substrates begin to move and need to be restrained, the plants are also subject to increased water stress. The problems can all be overcome with the right technologies, but costs increase.

Photo 13: Shaw's Cottage, Lewisham, London

iii. Planning Permission and Building Regulations

The policy environment and planning requirements are dealt with in the next section and although there are no explicit policy drivers in the Liverpool context, there are also no barriers to green roof installation. Professional advice will ensure that consent is not delayed where permission has to be sought.

iv. Liabilities

Fire

Many of the materials and design specifications in the UK are based on German specifications (FLL) that has strict guidelines on the design of green roofs. These include high levels of fire resistance and fire proofing for membranes and other layers beneath the soils and vegetation, the use of firebreaks and the amount of combustible material permitted in green roof aggregates and soils:

- the substrate / soil should be at least 30mm deep;
- the substrate / soil should contain less than 30% organic matter;
- there should be a 1m wide gravel or slab 'fire break' every 40m (if the span permits);
- gravel / shingle strips should be provided around all structures penetrating the roof covering. These strips should be at least 300-500mm in width, or 1m in width where they are to act as firebreaks on large roof areas.

In Germany the use of green roofs is considered to provide a

protective barrier preventing waterproofing elements from catching alight and it is possible for building owners to get a reduction of 10-20% on fire insurance. Millions of square metres of green roofs have been installed in Germany and Switzerland over the last 25 years to these standards, so fire hazard should not be viewed as a barrier to roof greening. A recent statement (2008) in UK by a major building insurer warned of fire risk if the vegetation dries out excessively in a drought year[29]. This is in contrast to the assurance provided within the German system and suggests that it is a matter of design. Any doubts can be allayed by installing simple irrigation systems (a perforated pipe) that can be switched on in excessively dry periods.

Roof leakage

The substrate, vegetation and various other components protect the roof surface from harmful UV radiation, temperature and rainfall extremes, increasing lifespan by up two to three times. The life span of a standard roof's waterproof membrane is 20-30 years, whereas the condition of waterproofing underlying green roofs of similar ages has been found to be in excellent condition. Thus the major green roof manufacturers offer 15 to 25 year guarantees depending on the type of waterproofing installed[30] so again, with careful installation leakages should not be seen to be a problem.

To avoid penetration through the roof, the waterproofing layer should be 150mm above the growing layer at abutments and integrity tests should be carried out on the waterproofing layer before laying the green roof. Adequate drainage will help to reduce ponding, so flat roofs should be laid to a fall of 1:40 and drainage layers designed into the system—options include porous mats, corrugated plastics sheets, or granular material. Further protection, by providing additional root barriers, will need to be considered if planting includes aggressive rhizomes and the waterproofing membrane can provide this function if it complies with BS EN 13948, the standard for resistance to root penetration.

In the event of a leak being detected, finding the source will be no different whether a green roof has been installed or not as often, thermal insulation will be kept in place by paving blocks, pebble or sealed asphalt layer that will anyway disguise the exact location.

Health and Safety

There are two main health and safety considerations: the first will be during the construction of the roof and will be the same as for any roof construction process which is covered in the Construction (Design and Management) Regulations and the Working at Height Regulations issued by the Health and Safety Executive[31]. The second area of consideration will be post-construction and to do with access and liabilities; the former being dealt with in the planning application phase—ensuring that materials and design are of a high standard; the latter will be the same for any building owner to ensure that a roof does not pose a risk to those within the building or passing by and again will be looked at under a planning application and subsequently through adequate maintenance.

The provision of safety features on roofs that will be accessed for maintenance and amenity purposes will add to costs of installation:

[29] Insurers warn of fire risk from green roofs. Building. M Willoughby. September 2008. (Building website)
[30] The Green Roof Pocket Guide. The Green Roof Forum.
[31] http://www.hse.gov.uk/construction/index.htm

In the case of maintenance through the provision of anchor points and in the case of amenity, barriers to contain people within safe areas.

v. Maintenance Costs

The maintenance requirements of green roofs are site and circumstance specific, the key being good design and installation. Correctly planted, extensive green roofs are specially designed to be mostly self-maintaining and therefore usually only require the following minimal annual upkeep:

- Annual removal of unwanted weeds and saplings (*Buddleja sp.* are a particular problem in inner city areas);
- Annual clearing of drainage outlets (a requirement on all roofs);
- In severe drought some of the literature recommends that plants receive a small amount of irrigation via, for instance, a perforated pipe (although this is largely unnecessary in the UK's climate)—this will depend on the species used on the roof and is not necessary for biodiverse roofs;
- Annual inspection of visible sections of waterproofing layers.

The first year will require a higher level of maintenance—for example watering in a very dry year when planted—than in subsequent years. It is therefore advisable to include a maintenance deal of two years in the installation contract to ensure the initial establishment and upkeep of plants[32].

Photo 14: Poplar seedlings growing in *Sedum sp* roof

vi. Limited Biodivesity and Amenity Value

A roof habitat will never fully replace a ground-level habitat as there will be limitations (height, habitat connectivity) on the number of species that can colonise the space. Also some types of roofs (biodiversity roofs, brown roofs, rubble roofs) are not green. Even the *Sedum sp*. roofs only flower in season (May to September) and may have a brown appearance in the winter and drought periods. Finally, if the installation of a green roof has strained the project resources, the roof, once installed, may have sufficient strength to carry substrate and vegetation, but not the capacity to carry significant numbers of people, so limiting access to a few people at a time. There are therefore genuine concerns whether green roofs will meet all expectations.

There are a number of ways that these issues can be dealt with in the design phase:

- Roofs often have differential loading capacities and those areas with higher loading capacity could have increased access designed into them, limiting access elsewhere where loading capacity is weak.
- 'Brown roofs' could have design features built in to create variety, such as different coloured substrates in attractive patterns—reminiscent of Japanese style gardens.
- Meadow wild flowers can be sown into the substrate to help with colonisation. The species that can be considered include:
  - Perforate St John's Wort – *Hypericum perforatum*
  - Yellow-wort – *Blackstonia perfoliata*
  - Common Centuary – *Centaurium erythaea*
  - Kidney Vetch – *Anthyllis vulneraria*
  - Common Bird's-foot-trefoil – *Lotus corniculatus*
  - Black Medick – *Medicago lupulina*

[32] The Green Roof Pocket Guide. The Green Roof Forum.

Dove's-foot Crane's-bill – *Geranium molle*
Common Eyebright – *Euphrasia nemorosa*
Betony – *Stachys officinalis*
Devil's–bit Scabious – *Succisa pratensis*
Ribwort Plantain – Plantago lanceolata
Selfheal – *Prunella vulgaris*

- A proportion of non-native flowering plants and / or shallow water features could be deisgned in to provide colour and interest. The MERCI project in Manchester had a shallow 'pond' installed for this reason[33]. Developers and planners should not fear that the 'eco-police' will dismiss proposed green roof projects that do not include the highest level of biodiversity outcomes, as any gain is better than no gain at all.
- Inclusion of habitat piles and nesting boxes and the sowing the substrate with appropriate seed mixes will increase the likelihood of species colonising the roof space. Advice from ecologists will ensure that correct steps are taken.
- Clarify the objectives for the roof (biodiveristy, amenity, insulation, storm water management or a mixture) to ensure that expectations are at least partly met in the design phase.
- Education and awareness raising, which is dealt with in more detail in the last section, but 'users' or beneficiaries could be involved in the design and installation process to create a better understanding of the facility.

vii. No Return on Investment

The analysis shown in i). of the previous section—The Case for Green Roofs, Economic Benefits—ranks extensive or biodiverse roofs first when considering investment over the medium term. It is therefore tempting to say that it is necessary to take a long term view of green roofs to justify them. However, there are valid short term justifications:

- The occasional availability of funding for green roofs, especially if it is a biodiverse roof, will clearly off-set investment;
- Green roofs can be used to achieve an 'Excellent' BREEAM rating;
- Green roofs can be used to achieve compliance with SUDS;

If the roof is designed into the project from inception, then it is possible to complement other project objectives with minimal additional cost.

Other aspects have already been discussed, but include a desire to create an environmentally conscious corporate image for the developer or the building owner. However, it is clear that the case for green roofs would be made stonger by stipulation through planning regulations and the provision of financial incentives (such as in many German and North American cities) to provide sustainable solutions for storm water management and reducing carbon footprint.

viii. Lack of Understanding and Awareness

As has been indicated earlier, many view green roofs as outlandish[34] with the perception coming from a number of different sources:

- Green roofing is not part of traditional built structure and so falls outside the remit of many technicians;

[33] Roof Greening in Greater Manchester; A Review. D Richardson, G Jones. 2008

[34] Planting Green Roofs and Living Walls. Nigel Dunnett, Noël Kingsbury. Timber Press 2004.

- Green roofs are seen as non-essential or aesthetic add-ons, rather than as an integral part of the building's structure;
- Green roof contribution to building objectives are poorly understood;
- Green roofs are often not green and are almost never gardens in the usual sense;
- Guidelines and specifications are not readily available;
- Costs and benefits are not readily available.

Much of the lack of awareness can be dealt with through placing roof greening on the policy agenda in such a way that building designers have to consider installation as one of a number of options to meet building objectives. The creation of standards, guidelines, cost / benefit ratios (NPV) to aid project managers make decisions will go a long to helping overcome many of the barriers to improved perception. Involvement of users and beneficiaries in the design and even building stage will help develop a significant understanding of the roof and its objectives among neighbouring communities. Finally a programme of promoting green roofs will help to promote roof greening to the wider public which can be fulfilled by a Liverpool-based organisation taking a lead in promoting roof greening at appropriate meetings, conferences, seminars, trade shows witihin the City.

The Policy Environment

The majority of the world's population is urbanised and the size of cities and proportion of people living in them is set to rise. Whereas urban planning has often looked at compacting urban populations to improve the efficiency of transport systems and communication networks, less consideration has been given to the opportunity to experience nature at close proximity. There are now concerns that the chance to access green space is declining in many cities and this despite the benefits to health and well-being and the ability of the urban population to cope better with the stresses of living in large urban areas when able to do so.

Green space is therefore a key element of cities and has been examined across Europe, analysing the extent of parks, informal and informal green space. Land areas in 386 cities, greater than 25 hectares and with a population of more than 100,000 inhabitants were characterised using data from the European Environment agency. This covered 170.6 million people, or 34% of Europe's 2001 population. Although green space percentage can be calculated in a variety of ways the work showed:

- The percentage of green space varied from 1.9% (Reggio di Calabria, Italy) to 46% (Ferrol, Spain).
- About 45 million people have limited access to green areas in cities that had between 2 and 13% green space.
- Not surprisingly, the proportion of green space per person diminishes as population density increases—though not because green spaces had been built on, but because more people are crowded into the cities.

Regional patterns emerged showing:

- That cities in northern Europe tended to have greater proportions of green space than cities in the south.
- The amount of green space varies significantly with the lowest provision in southern and eastern Europe, the highest in the north and northwest—Cádiz, Spain and Reggio di Calabria, Italy have 3

- 4 m^2 of green space per person, compared with more than 300 m^2 per person in Liège, Belgium and Oulu, Finland.

Of the 67 UK cities looked at, a population increase was not matched by an equivalent increase in green space, with green space only growing at the same rate as the growth of the city area. This was shown to be in contrast with the trend in European cities as a whole.

The research emphasised the fact that urban residents have diminished access to green space as cities grow and it highlights the need to plan for green space within the urban infrastructure that should include trees planted in streets, home gardens, allotments[35] and by extension, green roofs.

A Review of Green Roof Policies World-Wide

A number of reports and documents start with the reminder that green roofs are not new, citing the Hanging Gardens of Babylon and turf roofs on farm houses in Scotland and Scandinavia, the latter being more in keeping with the concept of roof greening explored in this report as they are about insulation and protection. This section does not aim to look at the full context of green roofs (going back to historical examples), but instead aims to give a feel for what other countries and cities are currently doing.

Photo 15: Traditional turf roof on the Faroes Islands

The UK

According to the construction research body CIRIA: "The UK is far behind its European neighbours and green roof technology is limited to showcase buildings and 'green centres'." It suggests that the need for more green roofs is greater than ever since the move to develop more brownfield sites which will see the loss of essential urban green space. In Germany, the world leaders in roof greening, in 2001 13.5million m^2 of green roofs were installed, which is many times more than in the UK. In some of the provinces in Germany, green roofs are a statutory requirement and grants are made available to act as an incentive and cover the additional costs. Green roofs are increasingly coming on to the agenda in the UK. Many local authorities are considering introducing a requirement in their local plans. The London Plan currently encourages their use, however, amendments are likely to be introduced shortly which will require their use in some situations and other cities such as Birmingham and Brighton are likely to follow suit.[36]

Photo 16: Sharrow School, Sheffield

Sheffield

Within the Sheffield City Council, the Environmental Planning Team considered the potential of green roofs and feeling that their inclusion made sense, spent a year talking to people in the City about green roofs.

A project was developed for the Norfolk Park Community Primary School, the first significant green roof, with clear objectives to minimise water run off from the roof, reduce vandalism and rain noise on metal roof. As time passed, other projects began to develop in both the public and private realm.

[35] The scaling of green space coverage in European cities. Fuller, R. A. and Gaston, K.J. (2009). Biology Letters. doi:10.1098/rsbl.2009.0010.

[36] Are green roofs just too radical? July 2007. http://www.sustainable-build.com/Articles/tabid/92/articleType/ArticleView/articleId/330/Are-green-roofs-just-too-radical.aspx

A significant development was the formation of a Green Roof Forum and the arrival of a partner in Groundwork Sheffield, who were able to run the forum and assist with funding bids to support the green roof 'process'. A key step was to bring the Development Control Officers on board, with some becoming keen on the sustainability aspect of green roofing, supported by other parts of the Planning Department. However, there was still no specific policy to support Green Roofs, but again things moved forward with an Environmental Strategy Manager appointed at senior level working across the whole Council, who was able to co-ordinate all the strands and generally keep the environment high on the policy agenda.

Photo 17: A bus shelter, Sheffield

Sheffield has addressed the policy issue through Development Control as it was felt that most green roofs will be on new developments, nearly all of which need planning. In terms of policy development, The Green Roof Forum sought to get green roofs on all medium or large developments within 100m of the green belt, green network, waterways, parks and open spaces greater than 1 hectare which was later simplified for a period of consultation in which the policies were refined and then subject to public examination by Planning Inspector[37].

The Green Roof Centre (a collaboration between Sheffield University and Groundwork Sheffield) are currently looking at producing British building standards for green roofs to provide Development Control with confidence to consent and act as precedent.

Manchester

There is no outright policy to install green roofs in Manchester, however, the City Council has been promoting green roofs since the launch of the Biodiversity Strategy in 2005 to help meet biodiversity targets—within the Greater Manchester Black Redstart BAP there is a target for 50 green roofs in 5 years. Although promoting green roofs and awareness-raising has figured strongly in the first phase of roof greening, 25 planning approvals with green roofs as a condition have gone to consent across the City to date.

Photo 18: Unicorn Grocery, Manchester.

The second phase in roof greening has seen the commissioning of a study to scope a realistic work programme, produce a Greater Manchester-specific guidance document for developers, architects and planners and will deliver feasibility studies for existing buildings in the Oxford Road Corridor area of the City.

London

A key motivator to the development of the green roof policy was also the protection of the black redstart *(Phoenicurus ochruros)*, an endangered bird that breeds and nests in urban brownfield sites in the Greater London Area. In London, the Mayor's Biodiversity Strategy supported green roofs, saying that "providing suitable substrates on roofs will allow wasteland flora and fauna to colonize naturally." It mentioned the physical and psychological benefits that are afforded to London's residents by greater contact with green spaces. The greatest endorsement of green roofs then came from the Wasteland Biodiversity document which states "where wasteland habitats are lost to development it is important that mitigation and compensation should concentrate on provision of similar habitats...such as creating wasteland habitats on roofs".

[37] http://www.shef.ac.uk/landscape/greenroof/pdf/keithmissen.pdf

The Mayor and surrounding Boroughs now expect that major developments incorporate living roofs and walls where feasible and reflect this principle in LDF policies. It is anticipated that this will include roof and wall planting that delivers:

- accessible roof space
- adapting to and mitigating climate change
- sustainable urban drainage
- enhancing biodiversity
- improved appearance.

The GLA and Boroughs should also encourage the use of living roofs in smaller developments and extensions where the opportunity arises.

Photo 19: Intensive green roof, London

CHINA

China appears to be encouraging green roof development for environmental reasons, where energy consumption can be reduced and storm water runoff reduced or controlled. At present there is no law that promulgates roof greening, but government departments are being encouraged to emphasise environmental protection projects, including energy efficient buildings. Some of the more progressive cities are beginning to provide financial incentives to developers that incorporate energy efficient technologies in design and green roofs fall within the category of such roof technologies.

Beijing

The city planned for a green infrastructure coverage of 45% by 2008 (to coincide with the Olympic Games) and rooftops became an obvious area to exploit in the effort to achieve the target, when land prices were so high and pressure to develop enormous.

Photo 20: Roof top garden, Beijing

It was considered that the impact of such a transformation would be to reduce carbon dioxide levels by 80% and would require a 70% coverage of available roof space with green roofs which translates into something like 69.79 million m^2. Staff within the Beijing Bureau of Parks and Woods indicated that the annual rate of roof greening will be maintained at a level of between 250 - 300,000 m^2 per annum. It has not been possible to verify whether the targets have all been met[38].

NORTH AMERICA

Directives for roof greening appear to be growing in North American cities. Various organisations offer financial incentives for green roofs that improve energy efficiency on commercial and institutional buildings. Green roofs can also earn LEED points, which is an incentive for developers seeking Green Building certification in both the USA and Canada.

The main motivation appears to be storm water management.

Portland, USA

Portland promotes green roof development through a number of policies, but requires green roofs only on public buildings. The following summarises Portland's efforts:

[38] The Greening of China's Building Industry. The China Business Review. K Langer, R Watson. 2005

- All new City-owned buildings are required to be built with a green roof that covers at least 70% of the roof space. All roof replacements must also include a green roof. The City has internal consultants to assist City buildings in meeting policy objectives. Most public green roof projects have been financed using 'storm water' fees.
- The City offers developers floor area 'bonuses' when they implement stipulated options, like a green roof. The building owner must sign an agreement ensuring proper roof maintenance.
- Portland levies a storm water management charge for commercial, industrial and institutional ratepayers that is based on the amount of impervious area on site.

Photo 21: Multnomah County Building, Portland

Promotion of green roofs has been effective to the extent that private individuals are starting to build or install them on their own initiative. However, green roofs have not yet taken off in the industrial sector.

Chicago, USA

Chicago is considered the leading proponent for green roofs in the USA and has a variety of policies and programs that encourage green roof development:

- The 2001 Regulation called the Energy Conservation Code requires that all new and retrofit roofs should meet minimum standards for solar reflection (0.25 reflectance). Chicago's Bureau of the Environment deemed that green roofs are an acceptable way to lower roof reflectivity, mitigate UHI and improve air quality.
- A 'Building Green/Green Roof' policy applies to construction projects that receive public assistance or certain projects that are subject to review by the Department of Planning and Development. Through this policy, the City of Chicago grants a density bonus option to developers whose buildings have a minimum vegetative coverage on the roof of 50% or 2,000 sq. feet (whichever is greater), usually in the form of a green roof.

Photo 22: City Hall, Chicago

As of June 2004, Chicago had more than 80 green roofs over municipal and private buildings in various stages of installation. The total area of these roofs is over 1 million square feet.

Toronto, Canada

The key motivators for the City of Toronto are reduction of storm water runoff, especially in areas overflow of combined sewers; reduction of urban heat island effect and replacement of displaced green spaces.

The city's involvement in green roofs goes back to the recommendations of the 2001 environmental plan, which first identified the need for a strategy to encourage green roofs and rooftop gardens. The natural environment policy within the City's new official plan supports "the development of innovative green spaces such as green roofs and designs that will reduce the urban heat island effect" and The *Wet Weather Flow Management Master Plan* for Toronto, completed in 2000, examined ways to improve the water quality of local rivers and Lake Ontario by strengthening mechanisms to prevent and reduce storm water runoff. Green roofs may appear in future storm water-planning policies.

Photo 23: Mountain Equipement Co-op green roof, Toronto

Some 6,200m^2 of green roof were installed under these policies by 2005 and installation continues to date, with lessons learnt being channelled into design innovation.

GERMANY

In Germany the dramatic increase in green roof construction can be attributed to legislation that is linked to community benefits. Experience has shown that it is not sufficient to rely solely on the goodwill of the building owners, but rather, that it is necessary for government to introduce green roof policies[39]. The total area of flat roofs built in Germany by1997 was 90 million m², this having gone up from approximately 0.6 million m² in 1983, to 8 million m² in 1993 and 11 million m² in 1997.

Stuttgart

Stuttgart promotes green roof development in three ways:

- The City has an annual budgetary allocation for green roof installation on public buildings with most green roofs being installed when the roof is due to be replaced. Authorities have provided a financial incentive for green roofs since 1986. The programme has €51,000 available a year, pays for 50% of the costs, or up to a maximum of €17.90 / m^2.
- The City provides a free consultation service and a comprehensive brochure to property owners explaining how to install green roofs.
- The City has regulation requiring all flat and slightly sloped roofs (up to 12º) of new development to be greened to certain standards. Trade-offs or compromises with developers are common.

Photo 24: View of Stuttgart's green roofscape from the Chinese Gardens

All three approaches have been successful and 105,000m2 of public roofscape have been greened, with 55,000m^2 of roof greened through the incentive program.

AUSTRIA

Linz

The City of Linz uses a combination of legal framework, financial grants and policy incentives. In 1985 legally binding development plans required green roofs and a green roof subsidy was implemented in 1989, marking the first direct financial incentive in Austria. Linz has approximately 440 funded green roofs with a total greened of about 500,000 m^2.

Photo 25: Aerial view of green roofing, City of Linz

SWITZERLAND

Basel

Basel has promoted green roof development through a number of policies. Specifically:

- In the mid-1990's, after a public poll found general support for an electricity tax to promote energy saving measures and after consultation with stakeholders, Basel invested 1 million SFr. from

[39] Green Roof Policies: Tools for Encouraging Sustainable Design, December 2004. Goya Ngan. Quoting – Landskron, Jürgen. 1998. Die Schlüsselrolle hat die Gemeinde. *DDH Edition Gründach Band 4.* Rudolf Müller Verlag, Köln.

electricity fees into a two-year incentive program, providing a subsidy of 20 SFr/m^2 of green roof. The programme was repeated in 2005/6.
- Since 2002, building regulations stipulate that all new and renovated flat roofs must be greened to provide valuable habitat (primarily for invertebrates), using specified materials.
- The City provided a grant for research on the biodiversity protection benefits of green roofs. The results of this study shaped the design specifications for green.
- Basel promoted the programme by holding a contest for the best looking green roof.

Photo 26: Convention Centre, Basel

In 1996/7, there were 135 applicants for the green roof subsidy and 85,000m^2 of roofscape were greened, resulting in 4 GW/year of energy savings. As a result of the regulations for new and renovated flat roofs, 15% of flat roofs in Basel have been greened. Basel is now exploring ways of enforcing proper green roof quality.

The UK

Unfortunately from the national perspective, there is not a great deal of explicit support for roof greening.

> "There are no planning or building codes to encourage the design and implementation of green roofs in Britain. National planning policy neither directly refers to green roofs nor implicitly includes them. There are no government incentives or support for green roofs. The first Urban White Paper in the UK in over 20 years—a report that calls for the renaissance of urban design quality and deeper community capacity-building—does not mention green roofs.
>
> "The Government's £22 billion Sustainable Communities Programme, launched in February 2003, sets out a program of action to address a range of fundamental infrastructure issues within the context of the shortage of housing across the UK. A demand for 4.4 million new homes is predicted by 2021. Green roofs are appearing as just one of a fairly complex recipe of sustainability features to meet increasingly rigorous environmental impact criteria." [40]

However, it is in the detail of creating sustainable living areas that support for roof greening can be found, especially in the role that green infrastructure in the urban environment can play. This is an issue that is dealt with in some detail in the next sections.

Green Infrastructure and Green Roofs in the North-West

In the North West Green Infrastructure Guide, green infrastructure, as opposed to the built or 'grey' infrastructure, is defined as a region's support system—the network of natural environmental components and green and blue spaces that lies within and between cities, towns and villages which provides multiple social, economic and environmental benefits[41].

[40] Green Roofs. A Resource Manual for Municipal Policy Makers. Lawlor, Currie, Doshi, Wieditz. May 2006.
[41] North-west Green Infrastructure Guide. NW Green Infrastructure Think Tank. Version 1.1, 2007.

The Guide talks of needing to find a joined-up and cross-regional approach to planning the region's infrastructure (including green infrastructure) and is seen as crucial within a context of climate change, increasing development pressure and rapidly changing business and agricultural landscapes.

Although the greatest bulk of green infrastructure lies out in the countryside, between the towns and cities, arguably the green infrastructure of immediate importance to society, is that within the towns and cities. The majority (about 4 million) of the region's population (6.8 million) lives within the nine largest cities and towns, most of which have a strong industrial heritage.

Green infrastructure within the built environment is considered important because it is integral to the economic development of an area in that it can:

- Contribute to climate change adaptation and mitigation;
- Assist in flood alleviation and water management;
- Help improve quality of place;
- Contribute to health and well-being;
- Improve land and property values;
- Contribute to economic growth and investment;
- Assist in increasing labour productivity;
- Contribute to tourism;
- Contribute to recreation and leisure;
- Help improve land and biodiversity;
- Contribute to production from the land.

Green roofing is part of the green infrastructure of a city, but is an even more direct link into the built environment by being located within or on a building and can contribute to most, if not all of the benefits listed for green infrastructure generally. However, any single green roof will demonstrate a range of these benefits depending on ownership, location, the potential for public access and whether it is a new-build or a retro-fit roof. In a city centre where land is at a premium and green space is often squeezed out by land prices, infrastructure and building density, roof-top spaces will become increasingly important as potential areas of green infrastructure and in many cities are an under-developed territory.

A Review of Liverpool's Policy Environment

There are two elements to the consideration of the policy environment in Liverpool: The first being development control that regulates new building and redevelopment; the second being the policies that promote the installation of green infrastructure systems such as green roofs. In a city centre, where land is at a premium and green space is often squeezed out by land prices, infrastructure and building density, roof tops are often an overlooked opportunity to increase the green infrastructure.

Development Control

The granting of planning permission is a complex process and cannot be easily summarised, but in general it will be dependent on whether the applicant can demonstrate a commitment to achieving good design, ensuring accessibility and whether the work to be undertaken will meet the various obligations within the relevant legislation and policy. In some instances an application can achieve this is by submitting a Design and Access Statement (a statement covering design concepts and principles and access issues).

In terms of a green roof installation the technical key issues will be:

- Load bearing – a load survey will have to be presented to demonstrate the ability of the roof structure to bear the loads imposed by a saturated medium at the thicknesses proposed along with additional loads imposed by amenity use.
- Waste water – a drainage survey will have to be presented to demonstrate the ability of the drainage systems to deal with storm water runoff.

In addition, there may also be issues of:

- Visual amenity – if overlooked, will the roof have a visual impact on adjacent properties?
- Residential amenity – if overlooked, is the roof easily accessed, is it open to the public and will the use patterns affect neighbours?

Almost all new developments will require planning permission and a green roof incorporated into a new development will be part of that application and may help an applicant provide benefits to satisfy planning policy requirements; for example sustainable drainage, reduced energy consumption, improved biodiversity and better air quality.

'Retro-fitting' a green roof to an existing building may also require planning permission if it involves an engineering operation in order to prepare the roof for planting, or implies a change of use, the loss of residential amenity or most importantly affect the appearance of the building. These points should always be confirmed with the planning authority and it is assumed that a project manager will employ a structural engineer to advise on load bearing and drainage capacity.

The Policy Environment

Policy, strategies and legislation that will impact on roof greening in Liverpool is set at national, regional and local level:

International	EU directives generate national legislation and those that impact on green infrastructure include: (i) The Water Framework Directive (2000) (ii) Landfill Directive (1999) (iii) Air Quality Directive (1996) (ii) Habitats Directive (1992) (iii) The Birds Directive (1979)
National	Wildlife & Countryside Act (1991); Natural Environment and Rural Communities Act Duty (2006), particularly the duty to conserve biodiversity; PPS 9 – Biodiversity and geological conservation; PPS 25 – Development and flood risk provision Sustainable Drainage Systems (SUDS); PPS 3 – Housing, well designed and energy efficient; PPS 1 – Delivering sustainable development, general policy and principles Securing the Future – Sustainable Development Strategy; New Building Regulations – Part L, Conservation of Fuel & Power; The DEFRA strategies 'Future Water' and 'Making Space for Water'.
Regional	Regional Spatial Strategy for the North West (RSS). The North West Regional Assembly produced the RSS

	together with all Local Authorities in North West England and adopted it September 2008. The RSS provides a framework for the physical development of the region over a 25 to 20-year period. It addresses the scale and distribution of future housing and it sets priorities for transport infrastructure, economic development, agriculture, minerals and waste. It therefore covers most of the range of the built or grey infrastructure and it provides a framework for dealing with environmental issues. The importance of the RSS is highlighted by the fact that every Local Development Framework, prepared under a statutory duty by all local authorities, is required to be in general conformity with the provisions of the RSS. Planning applications will therefore be considered against the provisions of the RSS[42]. The policy within the RSS that pertains directly to green infrastructure is: Policy EM3 – Green Infrastructure A Green Infrastructure Guide for the North West was produced in 2008 which provides more detailed guidance and will assist the way this policy is put into practice.
Local	Unitary Development Plan which was adopted in November 2002; The UDP has with it a range of Supplementary Planning Guidance (SPG) notes. These set out more detailed guidelines for certain types of development, such as house extensions and shopfronts, but also gives clear guidelines for the protection of open and green space. In September 2004, the English planning system was changed requiring that the UDP and all SPGs will be replaced by a new range of policy documents which, together, will be known as the Local Development Framework (LDF). All councils are required to plan for green infrastructure within their core strategies as directed in the national Planning Policy Statement 12 (PPS12) - Local Spatial Planning.

National planning guidance states that local authorities should promote 'resource and energy efficient buildings', the sustainable use of water resources, the use of sustainable drainage systems in the management of runoff. The Government also encourages local authorities to promote a greener residential environment and stipulates that development should be sustainable by ensuring that biological and geological diversity are conserved and enhanced.

In addition there are several national strategies that lend authority to the promotion of green roofs in development projects: The DEFRA publications 'Future Water' and 'Making Space for Water' promote the Environment Agency as the body responsible for taking a strategic overview of inland flooding. The focus on water management confirms the role of green infrastructure as part of a range of solutions to managing water runoff and storage—roof greening clearly offers opportunities to help meet strategic targets.

[42] Developing an outline strategy for linking green and grey infrastructure. Natural Economy Northwest. 2008

Planning Policy Statement 9 (PPS9) Biodiversity and Geological Conservation has as one of its key principles: *"the aim of planning decisions should be to prevent harm to biodiversity and geological conservation interests"*. It requires that local authorities take measures to protect the habitats of species of principal importance for the conservation of biodiversity and to refuse permission where harm to the species or their habitats would result, unless the need for, and benefits of, the development clearly outweigh that harm. Species of principal importance are defined under Section 74 of CRoW 2000 and include a variety of plant, bird, bat and invertebrate species. It also seeks to strengthen the protection given to networks of habitat, for example wastelands, woodlands, grasslands, including those within urban areas—it is here that green roofs can play a particularly important role.

Public Service Agreements – one area not touched on so far is the Government's recent Comprehensive Spending Review 2007 (CSR07) which continues to give emphasis to the use of Public Service Agreements (PSAs) as a method of driving up standards of public service delivery. Some 30 new and revised PSAs have been published and it is possible to identify how each PSA might impact on the interface between the built and green infrastructure, with the result that there are likely to be opportunities for green infrastructure to mitigate the deleterious environmental impacts that might result from increasing the amount of grey infrastructure[43].

Building Regulations contain no direct reference to green roofs, only to the general standards of roof construction and it is not a problem for green roofs to be constructed to meet these standards. There is reference to green roofs, but no design guidance, in BS EN 12056:2000 (Gravity Drainage Systems inside buildings Part 3 roof drainage layout and calculation) and there is no other British industry standards referring to green roofs. It is reported that the Green Roof Centre in Sheffield has embarked on a project to develop standards within a period of about 12 months (towards the end of 2009). Part L of the Building Regulations (updated in 2006) aims to substantially increase the energy efficiency of new and existing buildings in a variety of ways including higher standards of insulation. Green roofs and walls can make a contribution towards increased insulation, especially where retrofitted on to buildings with insulation levels that do not meet the new standards.

At the local level many authorities have no specific, named green infrastructure policy in their adopted development plans as the term was not in-use during production of the Unitary Development Plans (UDP). However, within existing adopted plans there are policies on protecting open space and important habitats as directed in the Local Spatial Planning Statement, PPS12. As the older style UDPs and Local Plans are revised and brought into line with current government guidelines they will incorporate 'green infrastructure' issues.

The planning framework is not prescriptive at the local level and tends to be highly variable across the country, with cities like Manchester, Sheffield and London putting issues like green roofs high up on the agenda (see overview), but currently Liverpool has no such policy in place—the City Council is in the initial stages of a complete review of its planning policies in preparation for writing the Local Development Framework (LDF). The first key stage in delivery of the LDF involves

[43] Developing an outline strategy for linking green and grey infrastructure. Natural Economy Northwest. 2008

preparation of the Core Strategy and the Council consulted on the Preferred Options for the Core Strategy between March and May 2008. A revised Preferred Options report will be consulted on towards the end of 2009 and will include consideration of green infrastructure issues.

Quality Markers

There are a series of tools used within the construction industry that provide environmental standards of best practice. These include BREEAM, EcoHomes, CEEQUAL and NEAT and provide:

- market recognition for low environmental impact buildings;
- assurance that best environmental practice is incorporated into a building;
- inspiration to find innovative solutions that minimise the environmental impact;
- a benchmark that is higher than regulation;
- a tool to help reduce running costs, improve working and living environments;
- a standard that demonstrates progress towards corporate and organisational environmental objectives[44].

BREEAM (BRE Environmental Assessment Method) is a tool to allow review and improvement of environmental performance throughout the life of commercial buildings. It is a widely accepted and respected scheme in the industry that sets a benchmark for environmental performance and provides a wide range of benefits. It is independent and authoritative, being based on many years of construction and environmental research carried out at BRE. The highest standard of 'Excellent' can only be achieved by incorporating features such as roof greening in the design.

EcoHomes is the version of BREEAM that is used for assessing new homes. The 2006 edition provides the opportunity to gain credits by incorporating rainwater holding facilities and /or sustainable drainage techniques including green roofs, biodiversity enhancements and features that minimise emissions of carbon dioxide to the atmosphere arising from the operation of a home and its services. All public funded housing from 2006 has to achieve EcoHomes Very Good rating; green roofs and walls could make a valuable contribution towards realising this. EcoHomes is also becoming embraced and eventually will be replaced by the DCLG's Code for Sustainable Homes.

CEEQUAL (Civil Engineering Environmental Quality Assessment and Award Scheme) rewards high environmental quality in civil engineering projects. Ecology is one of 12 criteria used to assess a project and credits are given for best practice in respect of a range of issues including legal compliance, conservation and enhancement of biodiversity, habitat creation measures, and monitoring and maintenance.

NEAT (NHS Environmental Assessment Tool) NHS Estates has developed a self-assessment scheme called NEAT. The aim is to raise awareness of the impacts that NHS facilities and services can have on the environment and estimate the level of environmental impact taking place. There is a focus on patient well-being and the positive effects that a green outlook can have on recovering good health. Green roofs and walls and the use

[44] BREEAM Web Site

of nest boxes could make a positive contribution to improve space and make better use of sunlight[45].

Potential for Green Roofs in Central Liverpool

Existing Green Roofs in the Merseyside and Surrounds

Toxteth TV

The Toxteth TV project manager sourced funding to assist with the installation of a biodiversity roof on one of the organisations' buildings, the John Archer Hall, an old school building. The primary aim being to enhance city centre biodiversity.

The roof was installed in June 2009, with advice from Biodiversity Manager for North Merseyside, The Reserves Manager, The Wildlife Trust for Lancashire, Manchester and North Merseyside and The Mersey Forest. More detail is contained in the section on the case study.

Martin Mere Visitor Centre and WWT offices

The turf roof was installed in 1976 to complement the log construction of what was a large roof-span building. It was replaced in 2001 and an improved waterproof lining was installed (the original felt layered lining had begun to leak) together with a new turf layer.

Experience has shown the importance of getting the waterproof layering right and of keeping the turf weed-free. However, some consideration is being given to sowing with a wildflower meadow mix.

Several hides on the reserve have also been roofed with turf roofs to help reduce the visual impact of the buildings.

Liverpool John Moores University

Several green roofs have been installed on new University buildings over the past five years. The first on the Cherie Booth Building on Byrom Street, installed in 2006 as part of improving the energy efficiency of the building; the second on the lecture theatre at the new Art and Design Academy off Brownlow Hill, having been completed in 2008, again part of improving energy efficiency of the building.

Neither building has public access and in the case of Cherie Booth building, access for maintenance will have to be via scaffolding erected for the purpose.

Chevasse Park

The major development at Liverpool One was completed with a car parking facility placed at the centre, but under the development. The roof of the car park was covered over and landscaped in 2008, replacing what was originally a small amenity park.

[45] BUILDING GREEN*er*: Guidance on the use of green roofs, green walls and complementary features on buildings. J Newton, D Gedge, P early, S Wilson. CIRIA. C644, London 2007.

The surface water discharging onto the park drains through the soft landscape materials, or in hard landscape areas via gullies and slot drains onto a horizontal drainage mat located above the roof structure's waterproof membrane. The drainage mat is protected from root penetration and the loss of fine aggregates by provision of a geotextile filter membrane. A collector drain feeds the water into a rainwater harvesting / attenuation tank. This tank allows rainwater to be recycled through the automatic irrigation for the park. The tank also provides attenuation to the peak flows from the park to limit the discharge into the sewers.

The roof beneath Derby Square access steps down to the north at the lowest point penetrations take water through to the 13 deck car park below.

Liverpool Echo Building

The Echo building was constructed in 1973. The roof, that is now a garden, covers the press hall and originally a water reservoir that was integrated into the printing systems occupied the roof space (the water was gathered from the Mersey Tunnel system). However, the reservoir was eventually removed in about 1990 because of concern for the machinery and printing systems below and a decorative garden installed.

The roof has an 8 inch cork/fibre insulation and 2 layers of waterproof rubber membrane with 18 inches of soil to provide a growing medium for grass and decorative evergreen shrubs, such as heather. Access is restricted to ensure that the membranes are not compromised and maintenance consists of clearing drainage systems and cutting and pruning the grass and shrubs.

The roof provides good insulation, preventing summer temperatures from rising too high in the press hall below.

Liverpool University, Ness Botanic Gardens

The Visitor Centre was built in the Botanic Garden in 2006 as part of a programme by the University to generate financial autonomy for the facility once the research programme was withdrawn back to a Liverpool centre by the Plant Sciences Department.

The *Sedum sp.* roof was installed as part of a revised building design to improve the 'green' credentials of the building. Plugs of 11 species of *Sedum* were planted into a thin soil over an aggregate mix. There is a 25 year guarantee on the membranes and insurance has not been an issue. Irrigation pipes have been installed in the event of needing to water the roof during excessively dry periods, but have not been used to date. Two years of maintenance were included in the installation contract.

The roof is proving to be a good insulator in the winter and together with the clear atrium roof and well insulated walls is keeping heating costs down, however in the summer the combination is too much and during sunny periods the building gets too hot. Some form of air-flow ventilation is needed to combat the effect of the clear atrium roof. It has been noticeable that tree seedlings (birch and poplar) are seeding into the roof, especially on the side of the roof facing the prevalent winds.

The Botanic Gardens have installed another very small green roof with a variety of *Sedum sp.* on a birch lean-to in the garden as part of a drive to promote green roofs for bee conservation.

The Context for New Green Roofs

Liverpool, the second city in the region, has seen radical changes over the last few decades having declined from one of the economic power-houses to the British economy. It had a thriving port through which 40% of the world's trade passed, an internationally important shipbuilding industry and a population in excess of 0.8 million. It is now a city in which population has fallen to about 0.43 million as a result of the decline in the manufacturing industry and closure of nearly all the port facilities (trade moving in the 1970s to a purpose-built container port in Bootle, at the northern end of the city). However, in the 21st Century growth in parts of the service, education and financial sectors has seen a resurgence of the economy and this, supported by money from European regeneration initiatives and the 2008 Capital of Culture has seen something of a revival of fortune. Many of city centre buildings have been refurbished or rebuilt with significant landscaping that has introduced green infrastructure into commercial and shopping zones in the form of trees, grass, shrubs at ground level. However, very few projects have included green infrastructure at roof level and the following sections look at the potential for green roofs in the future.

A Geographical Analysis

An attempt was made to establish the theoretical potential for roof greening in the centre of Liverpool. The boundaries of The Knowledge Quarter were established and all buildings within this area were surveyed using Ordnance Survey Master Map, reasonably up-to-date Local Authority aerial photographs and more recent aerial photographs from Google Earth. Once buildings had been identifying using Master Map, those with flat roofs or those with a very low angle of slope were selected using the aerial photos. The identified buildings were then counted, their roof area measured and added up to provide a figure representing total area of roof.

There are some 606 structures (see note), or 49.8 hectares with contiguous roof expanse within the Liverpool Knowledge Quarter boundary—which is about 178 hectares in total. Of those structures, 174 or 20.3 hectares are flat and therefore have potential for roof greening: This represents 11% of the total area or 41% of the roof area. It compares with the study in Manchester, where the figure was about 8% of the total area studied[46] and in London, where a study gives the area as about 6% of the total and 32% of the roof area[47].

[46] Roof Greening in Greater Manchester; A Review. D Richardson, G Jones. 2008
[47] Living Roofs and Walls. Supporting London Plan Policy. GLA. 2008

The fact that 174 or 29% of the structures make up 41% of the potential roof space is accounted for by the fact that the majority appear to be commercial buildings with large roof areas and the area looked at, being city centre, has a high proportion of commercial and business properties. Residential areas appear to provide very few opportunities for roof greening except on garages and outbuildings which don't always show up on the GIS maps or are too small to see on the aerial photos.

Several constraints in the interpretation should be noted:

- No attempt is made at estimating roof bearing capacity.
- The analysis did not exclude areas on large roofs that were occupied by machinery (air conditioning and extractors) or other structures. If this were accurately measured it would reduce the actual area available for green roofing.
- The analysis did not include angled roofs that were between 5 and 30 degrees in slope, so potentially there are other roofs that could be considered for roof greening.
- The word 'structures' is used to generalise the concept of a building as it is not known how many ownerships a large building is broken up into, nor where a building is divided under the roof area.
- Even in the very best of scenarios, the potential area will never be converted in full to green roof as, even if owners are willing, there are significant constraints to retro-fitting roofs to buildings given restrictions in access and loading.

The following diagram is a facsimile of a map produced from a GIS (geographical information system):

Potential Projects within the Merseyside

Despite the changes in certain areas of the city, some of the fabric remains unchanged, derelict or only partly refurbished. Many of the refurbishment and redevelopment projects will not have considered roof greening as an option, however, there still significant projects within, especially, the Knowledge Quarter that have potential roof space for installing green roofs.

The policy environment within which green roofing is being promoted is critical. Development control and building regulations are in place to ensure compliance with national and local development policy and it is important that green roofing projects do not conflict with existing policy, but contributes to it. It is essential that the development and building regulations framework is well understood to ensure that planning permission is applied for when necessary and that applications are well informed to ensure a smooth progression to consent.

For the benefits of green roofing to be realised it is essential that development and redevelopment policies promote and support green roofing, both in new buildings and retro-fitting to older buildings. In turn, building regulations will need to coincide with such a supportive policy to ensure that structural, waste water management and environmental regulations are maintained to the highest standard, but do not unintentionally militate against green roof installations.

The following is the potential that is currently known about:

- University of Liverpool
  There is a proposed residential development of 806 student beds plus retail on Mertyl Street which will have a Sedum roof. A planning application is due within the first half of 2009.

  The University is bidding into SALIX (a source of capital investment for universities for green projects) for funding which will probably include the upgrading of planned roofing work to include one or more green roofs.

- Royal Liverpool University Hospital
  The Hospital is currently drawing up a brief for the redevelopment of the hospital buildings and site. The brief will have a strong focus on sustainability, driven by the policy document Saving Carbon, Improving Health, produced by the NHS Sustainable Development Unit in January 2009 that sets out a Carbon Reduction Strategy for the NHS in England[48].

  The brief will be finalised later this year (2009) and will go out to procurement in the autumn. The bidders will be asked to consider green roofing as an option in the drive to reduce the hospital's carbon footprint, improve energy consumption, reduce waste water and other recurrent costs and help in the target of achieving an 'Excellent' BREEAM rating.

  Once the main hospital buildings have been constructed, further developments on the site of the old building, which may include medical related research businesses and facilities, could open up other possibilities for green roofing.

- Private Roofing
  A number of projects with green roofs are being considered, but at the time that this document was being finalised, no projects were in a position to commit to final design.

Finally, a second geographical analysis took a projection of the potential projects within the Knowledge Quarter and used the original analysis to estimate the area of potential green roof:

[48] Saving Carbon, Improving Health. NHS Carbon Reduction Strategy for England. January 2009.

The area of new roof (red lines) within the Knowledge Quarter is about 16.2 hectares and if the figure of 41% of roof area is taken as potential for green roof (see previous section), then the area of new buildings that could carry green roof would be about 6.6 hectares. As in the previous analysis this does not take account of bearing capacity, machinery and no effort was made to examine project design documents. The diagram also shows that some roof of the new buildings will replace older buildings that were considered suitable for green roofs in the original analysis (the green areas), but no effort was made to compute new potential total area as there would have to be too many assumptions to make the calculation.

A Liverpool Case Study

Toxteth TV

Introduction

Toxteth TV is a pilot project that provides training and education for school children and young adults who are interested in pursuing a career in media, giving them skills to progress in education and potentially on into employment. The project focuses, in particular, on young people who have been excluded from mainstream education or have under-achieved at school as well as school leavers who are looking at media as a career.

The project is housed in a group of buildings on Windsor Street, Toxteth that provide space for training and production. The centre boasts state-of-the-art studio facilities, but also provides affordable office accommodation for small film production companies and creative businesses. The studio is housed in a redeveloped, originally derelict, pub and has helped to transform the local area, sitting quite comfortably against the backdrop of Liverpool's Anglican cathedral. It has won numerous accolades, including recent awards for 'Best Regeneration Scheme' and 'Building of the Year'.

The John Archer Hall, an old school building, has recently been refurbished and adds to the resources that the project provides to businesses and the local community. As part of an on-going programme of improvement, a green roof has been installed on the building to provide an education feature, reduce utility and energy bills and help increase city-centre biodiversity.

The Roof Details

ITEM	COST	DETAIL
Building		John Archer Hall, (roof area previously used as a playground by the school), Windsor Street, Toxteth, Liverpool.
Roof area		140m^2 concrete slab roof.
Architect		Union North.
Builder		Evergreen Roof Gardens Ltd.
Planning permission		Planning consent obtained from Liverpool City Council – 2008, not overlooked, not listed, but 'engineering operations' and 'change of use' permission required.
Design and Access Statement	£350	Design and Access statement provided which included a sustainable transport options and servicing arrangement, together with information on anticipated pedestrian, cyclist and vehicular movements as a result of the proposal.

ITEM	COST	DETAIL
Waterproofing	£15,740	Synthetic rubber membrane (ethylene propylene diene-terpolymer EPDM)
Crane hire	£780	2 days @ £390 / day
Drainage layer		Oldroyd Xv20 Green Xtra with 20mm holding cups, plus top and bottom layer of filter fleece
Aggregate		Mix of fine to coarse aggregate and patches of sand / fine aggregate mix
Biodiversity features	£14,790	• 2 ponds, one rain-fed (ephemeral), one topped up with roof-drainage water • Wildflower seed mix broadcast on aggregate (obtained from National Wildflower Centre) • Deadwood logs for use as habitat piles • Bird boxes
Additional biodiversity features		• Waste water down-pipe to feed pond • Additional wildflower seed mix to broadcast
TOTAL	**£32,000**	

Construction

John Archer Hall:

Extent of the roof:

The waterproof membrane and the 20mm holding cups:

The fire 400mm fire retardant shingle strip and wheelchair access compliant path:

Laying the soil/aggregate – detail showing 'leca' additive to lighten the mix:

Aggregate overlying the filter fleece and completing the shingle strips:

Pond with waterproof liner and other biodiversity features being installed:

Detail of biodiversity features and sand feature:

What Next?

The Manchester City Council has contracted a consortium led by Drivers Jonas ppl to take The Greater Manchester Green Roof Programme forward into a new phase for implementation in Greater Manchester. In preparation a stakeholder workshop was conducted in May 2009 that explored a number of the issues that have been highlighted in this report.

As an outcome the participants of the workshop prioritised a list of the major issues that they felt had to be dealt with in by the programme:

- Lack of awareness about and understanding of green roofs;
- Lack of detailed, credible information about the costs and benefits of green roofs;
- Lack of definitive and authoritative standards for green roof construction;
- Lack of funding;
- Lack of political will within national, regional and local policy and planning structures;

- Lack of capacity and services within local systems (architects, developers, builders, planners, green roof specialists).

Shifting the emphasis back to the Merseyside, it is suggested that this list and set of priorities change little for Liverpool. Indeed, as the City has not explicitly addressed the green roof issue and green infrastructure policies are in their infancy, it may have the advantage of being able to draw on developments and progress elsewhere, most significantly:

1. The Green Roof Centre in Sheffield has taken the initiative to develop a building code for UK green roofs. The code is due out at the end of 2009 with the hope that the building industry will adopt the standards.
2. The Greater Manchester Green Roof Programme is looking to develop a series of case studies along the Oxford Road Corridor (the focus of the project) to explore in detail a number of issues, but in particular costs and benefits.
3. NW Climate Change Action Plan – The role of green infrastructure in climate change mitigation and adaptation in the North West is currently being investigated as part of the NW Climate Change Action Plan. The emerging Regional Green Infrastructure Climate Change Action Plan will highlight the need to moderate urban temperatures, reduce flood risk by managing surface water, provide 'climate spaces' to facilitate species movement northwards and provide green space resources within the grey infrastructure of the urban environment. Green roofs will be highlighted as an important element of this Action Plan, especially for city centres.
4. RS2010 – Work is being undertaken in the North West to integrate the Regional Economic Strategy (RES), the Regional Spatial Strategy (RSS) and the Regional Housing Strategy (RHS). The strategy will focus on the issues of sustainability, working to support key Government targets to reduce carbon emissions, create opportunities for work and healthier lifestyles and improve urban infrastructure. Green infrastructure will play an important role in helping to reduce carbon emissions and create better living spaces within urban areas. That green roofs will be an important tool within this strategy is implicit in good green infrastructure planning, but it is also hoped that, as the strategy emerges, they will be promoted explicitly.

If the figure of 6 hectares of potential green roof were taken as a very rough guideline or target, currently there are very few projects proposed (see Potential Projects). This leaves a great deal of work to be done to encourage developers, builders and project managers to install green roofs. In an effort to close the gap, it is suggested that the following is a way forward for Liverpool:

1. An organisation take on the role of champion for the promotion of green roofs in Liverpool and Merseyside;
2. Champions for green roof installation be sought within the political arena, the City Council planning department, among architects, developers, builders, environmental organisations;
3. A green roof network be established;
4. Funding sought to finance the next stage of development;
5. A steering group drawn from among the champions, set up to oversee progress;
6. An awareness raising campaign developed and implemented;
7. A programme of green roof projects developed at key sites and among key stakeholders, initially, but not exclusively, focussing on the Liverpool Knowledge Quarter;

8. Funding sought to assist in design and installation of good quality, biodiverse green roofs;
9. Dialogue developed with the City Council's planning department to inform green infrastructure policy development, ensuring that green roofs are explicitly mentioned and promoted;
10. Contacts maintained with Sheffield, the Green Roof Centre and Manchester City Council to share learning and developments and ensure that Liverpool is placed at the leading edge of green roof work in the UK.

Once a programme is in place that can take forward some or all of the recommended steps, a review of progress should be carried out one year into the programme answerable to the steering group.

Green Roof Resources

Reports and Guides

- Planting Green Roofs and Living Walls. Nigel Dunnet and Noël Kingsbury. Timber Press, 2004

- Roof Greening in Greater Manchester; A Review. D Richardson, G Jones. Natural Economy Northwest. http://www.naturaleconomynorthwest.co.uk/resources+reports.php.

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- Green roof toolkit. The Environment Agency. http://www.environment-agency.gov.uk/business/sectors/91967.aspx

- The Green Roof Pocket Guide. The Green Roof Forum. http://www.groundwork-sheffield.org.uk/upload/documents/document48.pdf

- BUILDING GREENer: Guidance on the use of green roofs, green walls and complementary features on buildings. J Newton, D Gedge, P early, S Wilson. CIRIA. C644, London 2007.

- Living Roofs and Walls. Supporting London Plan Policy. GLA. 2008. http://www.london.gov.uk/mayor/strategies/sds/tech_rpts.jsp

- Developing an outline strategy for linking green and grey infrastructure. Natural Economy Northwest. 2008. http://www.naturaleconomynorthwest.co.uk/resources+reports.php

Useful Links

Green Roofs Today online directory. http://www.greenroofstoday.co.uk/ With the facility to subscribe to a green roof newsletter "Green News Today".

The Green Roof Centre, Sheffield. http://www.thegreenroofcentre.co.uk/

Livingroofs.org.uk. http://livingroofs.org/

Brownroofs.co.uk. http://www.brownroofs.co.uk/

Natural Economy Northwest.
http://www.naturaleconomynorthwest.co.uk/

Natural England. http://www.naturalengland.org.uk/

FLL, The Landscape Research, Development & Construction Society (green roof standards, Germany). http://www.f-l-l.de/english.html

Construction Industry Research and Information Association, CIRIA web site. http://www.ciria.org/service/Home/

BREEAM Web Site. http://www.breeam.org/

The Health and Safety Executive.
http://www.hse.gov.uk/construction/index.htm

Green roof training, Groundwork Sheffield – The Green Box Group.
http://www.greenboxgroup.org.uk/

Sustainable Cities. CABE.
http://www.sustainablecities.org.uk/greeninfrastructure/integration/green-roofs/