Green Roof Policies:

Tools for Encouraging Sustainable Design

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1 Introduction

1.1 Purpose

"Like a tiny seed carried by a late summer breeze, the idea of cultivating plants on rooftops has spread from Europe to North America and around the world." (Dawson, 2002)

This report describes policy used in Germany to encourage the construction of green roofs. The underlying purpose of the report is to offer practical and attainable solutions for sustainable urban development. Specifically, it will assist Canadian municipalities in incorporating green roofs into their official plans, policies and operating procedures.

Since green roof policy in Germany is widespread and varied, this report gives a general description of the different types of policy and focuses on four examples to demonstrate how the policies may be implemented. The last chapter contains recommendations for Canadian policy makers who want to develop green roof policies.

1.2 Green Roofs: an Overview

Green roofs have been constructed for thousands of years, the most famous early example being the Hanging Gardens of Babylon. They have also been used in traditional buildings such as the sod roofs of rural Scandinavia. Experimentation in the earlier part of the 20th century found that green roofs required special waterproofing, since roots were found to grow into what were typically tar roofs. Over the past 35 years, research and experimentation has taken place primarily in Germany, where sophisticated waterproof membranes have been perfected, construction standards have been developed, and the environmental, economic and social benefits of green roofs continue to be studied.

With our environmental problems requiring urgent attention, many places in the world have become interested in green roof technology. A frenzy of activity has occurred in North America. It ranges from measuring the benefits of green roofs with scientific testing and monitoring, construction research and standards development, material and vegetation testing, and policy development.

Germany is recognized as a world leader in green roof technology, from both a theoretical and a practical standpoint. The German green roof construction trend began in the 1960's. When the first generation of waterproof membranes showed signs of damage in the 1970's, techniques were documented and materials were developed to respond to building design issues. By the 1980's much interest and research had gone into the ecological benefits of green roofs, resulting in a high demand for the newly coined "extensive" roof greening. The development of green roof technology included studies on using plant species which could maintain themselves indefinitely. At the same time, various jurisdictions and levels of government began implementing public policy to encourage green roof construction. Federal, state and municipal policies are now in place to encourage green roof construction. By 2001, nationwide, a roof area of 13.5 million m² had been greened (Mann, 2002a). Green roofs now make up 14% of total roof area in Germany (Herman, 2003). To give an idea of the extent of the industry, the 2002 Green Roof Yearbook (BGL, 2002) lists over 1200 landscape contractors in Germany that install green roofs. It also lists approximately 200 suppliers of green roof materials and products.

Intensive green roof

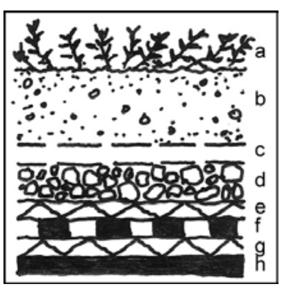
Extensive green roof

Green roofs can be divided into two categories: intensive and extensive. Intensive green roofs have greater planting medium depths in which any type of vegetation may grow, from lawn and groundcover to shrubs and trees. They are often accessible to people and activities and are often built in downtown areas where green space is limited. They represent highly artificial environments compared to ground-based gardens, requiring more irrigation, fertilizer, and care. Intensive green roofs are more costly than extensive green roofs to build and maintain.

Extensive green roofs are designed with minimal planting medium profiles and sometimes only a mineral substrate. The plants, normally mosses, succulents, herbaceous plants and grasses, are chosen for their ability to regenerate and maintain themselves over long periods of time, in addition to being able to withstand the harsh conditions of cold, heat, drought and wind. Native species are often preferred. Extensive green roofs do not necessarily require irrigation, and since they are often not accessible to the public, they have fewer other requirements, such as guardrails. Extensive green roofs are the least expensive form of roof greening to implement and maintain.

In Germany, the Landscape Construction and Development Research Society, known as the FLL (*Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V.*), publishes comprehensive green roof guidelines. The guidelines cover design, construction and maintenance with detailed sections on stormwater retention, planting medium requirements, drainage layer requirements and information on how waterproof membranes and root barriers are tested for suitability against root penetration.

There are many ways in which a green roof can be built, but even an overview of these methods is beyond the scope of this report. For the sake of discussion, a typical extensive green roof consists of the following components:



Green roof components

- Vegetation (a)
- Growing medium (b)
- Filter layer (c)
- Drainage layer (d)
- Protection layer (as required) (e)
- Root barrier (as required) (f)
- Separation layer (as required) (g)
- Waterproof membrane (h)

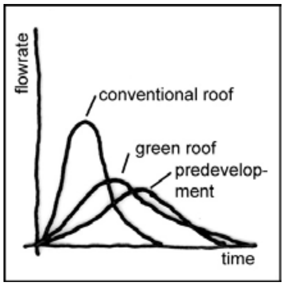
When chemically incompatible layers, such as bitumen and PVC, are planned to be overlaid, a separation layer is required. A root barrier is required if the waterproof membrane is not itself resistant to root penetration. The protection layer exists to prevent mechanical damage. The drainage layer is typically specified as a lightweight composite material or a prefabricated drainage system. The filter layer prevents fine particles in the growing medium from interfering with drainage and underlying components. The growing medium is usually composed of lightweight materials blended to achieve a certain particle size distribution, as well as other criteria.

1.3 Green Roof Benefits

The ecological, technical and social benefits of green roofs are recognized and accepted in many parts of the world. Canadian research results are becoming available from the National Research

Council research station in Ottawa and the BC Institute of Technology green roof research facility in Vancouver. However, the majority of research until now has been conducted in Germany.

Stormwater Management



Hydrograph

Green roofs can reduce the negative effects of stormwater in urban areas. Stormwater is retained in the green roof components where a portion of it evaporates and evapotranspirates thereby reducing stormwater volumes. The flow-through portion is delayed in its release. Therefore, the peak flow of a rainfall event which causes sewer overflow and pollution, as well as floods, is reduced with a green roof. With reduced stormwater volumes and peak flows, the load on sewerage infrastructure is less which can result in cost savings.

Green roofs absorb and filter pollutants from rainwater. The excess water which drains from a green roof can be infiltrated on-site using various source controls such as infiltration swales and trenches. Using these techniques, buildings with green roofs in Germany have been completely disconnected from the storm sewer system.

Recycled Water

In combination with cisterns, the water from green roofs can be used to irrigate the roof itself in times of drought as well as other landscaped areas; it can be saved for a fire reservoir, toilet flushing or car washing.

Greenhouse Effect

Green roofs reduce the greenhouse effect by absorbing carbon dioxide and producing oxygen. They also reduce solar reflection. Because of their effect on thermal performance, green roofs reduce the need for air conditioning which is itself a source of greenhouse gases.

Urban Biodiversity


Ladybug beetle on Sedum plant

Green roofs serve several functions related to urban biodiversity (Mann, 2002b). They act as stepping stones between nature reserves, such as parks on the edges of cities, and uncolonized habitats in the middle of the city. They provide a return area for plants and animals that previously inhabited an area that has undergone disturbance and development. They also can serve as permanent substitute habitats for plant and invertebrate communities. This last function is what the German Intervention Rule of the Federal Nature Conservation Act strives to achieve (see section 3.3).

Green roofs support invertebrates such as bees, beetles, butterflies, moths, earthworms and snails, and vertebrates such as birds. Biodiversity can be encouraged by maximizing structural diversity, varying the soil depth, using native soils, and growing plant species that serve as larval hosts and food plants for insects. Sedums are host plants for a variety of butterflies and moths.

In addition to fauna, green roofs can support special vegetation. A three ha green roof, constructed in 1914 near Zurich is home to 10,000 orchids including some rare species, as well as 175 native wetland plant species (Brenneisen, 2003).

Membrane Protection

Green roofs provide protection to the waterproof membrane in several ways. They moderate the temperature, thus reducing damage from expansion and shrinkage during alternating temperature extremes. They protect against damage from ultraviolet radiation. They provide protection from mechanical damage caused by hail, human traffic, etc. The membrane of a conventional roof needs major repairs or replacement about every 20-25 years. It is commonly believed that a green roof membrane may last twice as long. However, the modern green roof membranes have not been on the market for so long and their lifespan is untested.

Research conducted by the National Research Council (NRC) in Ottawa shows that on a hot summer day in 2001 with an outdoor peak temperature of 35ºC, the grey membrane of the reference roof reached 70ºC while the membrane on the green roof remained between 25 and 30ºC because of the shade and insulation provided by the growing medium. Daily temperature fluctuations were found to decrease from 46ºC on the reference roof to 6ºC on the green roof (Liu, 2002).

Thermal Performance

Green roofs improve the thermal performance of a building by reducing heat flow across the roofing system. Less energy is required to heat the interior space in winter and the need for air conditioning is reduced in summer.

The same research from NRC found that in spring and winter of 2001, the green roof reduced the overall heat entering the building during the day by more than 85% and reduced the heat leaving the building at night by about 70% (Liu, 2002).

Infrared aerial photographs have been used to compare temperatures between green roofs and conventional roofs.

Fire Resistance

Green roofs may protect buildings against fire, although research in this area is sparse. An investigation in Berlin into the resistance of green roofs to fire found that green roofs are more resistant that gravel roofs and that succulents such as sedum offer good fire resistance (Köhler, 2004). The “film bunker” at the UFA studios in Babelsberg was used in the 1930’s to store valuable film material such as the original Marlene Dietrich movies. The rooms were separated by thick brick walls and the tar roof was greened for added fire protection (Köhler, 2003a).

Sound Attenuation

Green roofs absorb sound through the vegetation and substrate mitigating the outside noise as well as the interior noise. This is a useful way to block noise from highways and airplanes.

Electromagnetic Insulation

Research in Munich and Kassel has found that electromagnetic radiation penetration is reduced by 99.4% with a 10 cm substrate depth (Herman, 2003). This may be a disadvantage for cellular phone reception, but on the other hand it may be desirable if the radiation is found to pose a health risk, as consumer groups in Germany now claim.

Improved Air Quality

Green roofs can alter the climate of adjacent areas to the benefit of local residents and employees. The air near green roofs in summer is cooler and more humid. Moreover green roofs bind dust and filter out air pollution making the air cleaner.

Urban Heat Island Effect

The urban heat island effect exists when the temperature in a city is drier and hotter than the air in the surrounding countryside. It is caused by changes in the natural water and energy balance, for example, through the process of urbanization or the sealing of previously pervious surfaces. Heat islands raise urban temperatures during the summer, which can increase the risk of heat-related illness and mortality. They also decrease urban ventilation and increase air pollution levels. Heat-absorbing tar and other dark roofing materials contribute significantly to higher temperatures.

Green roofs counteract the heat island effect by reducing impervious surfaces which cause temperatures to rise, cooling the air through the processes of evaporation and evapotranspiration, and keeping the rooms beneath the roof cooler. The latter reduces the need for air conditioning which contributes greatly to the urban heat island effect.

Tokyo suffers from severe urban heat island effect because of its wide expanse of impervious surfaces and urban machinery. According to the Japanese Meteorological Agency, the average annual temperature in Tokyo has risen 3ºC in the last century, a rise four times higher than what might be explained by global warming (Tracey, 2004). “The Tokyo-based Organization for Landscape and Urban Greenery Technology Development estimates that if half of the roofs in the city were planted with gardens, daytime high temperatures in summer would fall by 0.84ºC, which would save ¥110 million ($126 million Cdn) on air conditioning costs daily.” (Trautlein, 2003) Tokyo’s Shibuya ward has introduced policy that requires green roofs be installed on 20% of all new flat roof surfaces on government buildings and 10% of all new flat roof surfaces on private buildings (Sichello, 2004). This successful program has caused a growing demand for green roofs as well as more legislation to support them.

Aesthetic Value

Aesthetics are perhaps the most apparent benefit of green roofs. Indeed most of the green roofs found in Canada, are intensive roofs built for aesthetic or amenity purposes. Inaccessible extensive green roofs also have aesthetic value, especially when viewed from surrounding buildings.

Amenity Value

Accessible green roofs provide amenity space without taking up valuable ground space. Vegetable gardens are a popular use for roofs in Manhattan where ground-based gardens seldom exist. Aging populations will also appreciate places in which to cultivate plants. As populations become more urbanized, the need for urban green space is becoming more apparent.

> *“Is it not against all logic when the upper surface of a whole town remains unused and reserved exclusively for a dialogue between the tiles and the stars.”*
> Le Corbusier

Because of their aesthetic and amenity value, green roofs and rooftop gardens have positive effects on real estate values (Köhler, 2003b).

The FLL has a publication out on how to quantify the effect of green spaces on real estate values (FLL, 2000).

Therapeutic Value

There is mounting evidence to support the benefits of horticultural therapy. For health facilities with lack of ground space, green roofs provide a location for horticultural therapy programs to be implemented. A simple view onto an extensive green roof may help people recover more quickly from illness. “Records on recovery after cholecystectomy of patients in a suburban Pennsylvania hospital between 1972 and 1981 were examined to determine whether assignment to a room with a window view of a natural setting might have restorative influences. Twenty-three surgical patients assigned to rooms with windows looking out on a natural scene had shorter postoperative hospital stays, received fewer negative evaluative comments in nurses' notes, and took fewer potent analgesics than 23 matched patients in similar rooms with windows facing a brick building wall.” (Ulrich, 1984)

Ford Advertisement

Environmental Image

Both the private and public sector are using green roofs to maintain or improve their environmental image. Municipal governments, banks, insurance companies, automobile companies and others are building green roofs in both Europe and North America. For example, Chicago City Hall, Ducks Unlimited National Headquarters in Winnipeg, DaimlerChrysler in Potsdamerplatz, Berlin, Ford Motor Company in Dearborn, Michigan, and The Gap in San Bruno, California all have been built with planted roofs.

> “This is not *environmental philanthropy*. It’s *sound business.”*
> Ford Advertisement

On June 28, 2004, the Ford Motor Company placed an eight-page colour advertisement in *The New Yorker* which described the roof built in Dearborn, Michigan. Although their main purpose is increased sales, the green roofs will still provide environmental benefits.

1.4 Green Roof Barriers

As rich as the literature is in green roof benefits, it is poor in arguments against them. However, there are some barriers which should be addressed.

Cost

As with any other building activity, there are costs associated with green roofs. The question is whether the benefits outweigh the costs. It is important to separate intensive green roofs from extensive green roofs. Intensive roofs will have many requirements and extra costs associated with them but they are usually selected when the benefits are expected to be great. Similar to a garden or park project, the benefits are often difficult to quantify. A cost-benefit analysis for an intensive roof must be done on a project-by-project basis. Extensive green roofs are less expensive to build and maintain and those with very thin profiles sometimes do not require extra structural support. A cost analysis should take into account the full life-cycle costs, such as the extended lifespan of the membrane resulting from green roof protection. A green roof membrane will not require repairs for 40-50 years whereas a gravel-covered roof needs replacement after 25 years (Krupka, 2001). In Germany, annual stormwater fees also help to offset the green roof investment. When these fees are taken into account, extensive green roofs are often cheaper to build than gravel ballast roofs are. Many of the environmental benefits such as biodiversity and improved air quality for extensive green roofs are also not easily quantified. A tool (*Bewertung von Maßnahmen der Regenwasserbewirtschaftung*) is being developed and tested in Berlin to help developers with cost-benefit analyses which will factor in non-monetary aspects of sustainable design as well as the usual cost-analysis components (Reichmann, 2003).

Cost-benefit analyses will convince some owners and developers to build green roofs. Others will need more encouragement or even legislation and this report attempts to assist in developing incentives and policies for this to take place.

Repairs

The argument that repairs are more difficult on a green roof is partially justified. While it is costly to remove and replace green roof components, deficiencies can be avoided. They generally arise from faulty workmanship, faulty design, lack of or incorrect maintenance and occasionally from material failure. Extra vigilance is required at all stages.

Green roof membranes have high technical requirements similar to accessible roof surfaces such as terraces (Krupka, 2001). They cannot be compared directly to conventional roof membranes. Finding leaks is difficult for both green and conventional roofs because the place where water appears rarely corresponds to where it enters. The cause of the leak is first sought at edges and roof penetrations before looking under the main surface. There are search instruments that can precisely pinpoint the location of a leak using electro-impulse. Buildings with sensitive uses, such as archives or computer rooms, can be outfitted with leak sensors. In the case of single-course construction, the substrate can be re-used and normally additional planting is not necessary.

Aesthetic

Green roof in Dresden during a drought

Beauty is in the eye of the beholder and some may argue that extensive green roofs look messy and are not even green! The appearance of extensive green roofs should not be compared to lawn and traditional gardens. Extensive green roofs have a natural appearance that changes with the seasons. They are more similar to dry wildflower meadows and develop much in the same way as natural ecosystems. When we can associate how a healthy functioning extensive green roofs looks with the ecological benefits that they afford, then we will have an eye for sustainability. In fact, the City of Portland prefers the term “ecoroof” because it emphasizes the ecological function over the colour green (Hauth and Liptan, 2003). In some cases, aesthetics is a moot point. Whether the local Superstore is covered in red stonecrop or not is irrelevant; the only people who will see it are those in an airplane.

Lack of Expertise

Public opinion, whether based on fact or not, is a key factor in the support that green roof technology will have in the future. An inventory of green roofs in the Greater Vancouver Regional District found that people were mistakenly associating green roofs with the leaky condo crisis (Davis, 2002).

It is interesting to look at the development of the green roof industry in Germany. Robert Herman (2003) explains that “in hindsight, the major factor contributing to the public’s impression that green roofs can be problematic was the failure of many green roofs installed during the initial green roof construction boom. New, inexperienced companies simply made mistakes or installed poor quality, cheaper materials and “cut corners” in order to keep costs down. This form of negative advertising adversely affected the entire industry. The FLL guidelines are mainly responsible for reversing the downward spiralling reputation of green roofs.”

This observation is similar to that of Rudolf Gix (2003) who reported that during reunification in the early 1990’s, many commercial companies built outlets in the new states (former East Germany). Because this building surge tended to occur on previously undeveloped sites, the companies wanted to make a good environmental impression by building voluntary green roofs. Tengelmann and Aldi were among the supermarkets that tried green roofs on their 40-80,000 m² per project roof surfaces. Unfortunately, a lack of technical expertise and insufficient budgets resulted in deficient green roofs. The news of the poorly constructed green roofs became public and many companies stopped building them.

Lack of Research and Standards

A significant barrier now is that Canada has neither detailed design guidelines, standards that are integrated into local building codes, nor procedures for testing materials and new products. However, this shortfall is being addressed in several places throughout North America. The results of scientific research will soon be able to provide a basis for the development of standards.

The German FLL guidelines provide a source of information for the interim but they should be evaluated for their application to local building practices and climates in Canada. Building codes may need to be updated.

2 Policy Background

German green roof policies, many of which have been in place for over a decade, fall into four general categories:

- direct financial incentives;
- indirect financial incentives;
- ecological compensation measure; and
- integration into development regulations.

These categories are described in the following chapter along with their opportunities and limitations. Section 2.3 on legal framework is intended to help put the policies into the context of German federal laws.

2.1 Significance of Green Roof Policy

Green roof policy is intended to maximize the collective benefits of green roofs. Collective benefits are those which benefit the public at large, such as reduced stormwater runoff, climate moderation and thermal cooling.

Until recently, the building of green roofs in Canada has been a strictly voluntary undertaking. A recent inventory by the Greater Vancouver Regional District found 605 green roofs in the Lower Mainland alone. Green roofs were loosely defined in the inventory and include measures as simple as planters on roof decks. Only 30 of the 605 Vancouver green roofs are extensive or semi-intensive green roofs (Davis, 2002). Under the volunteer system, only direct private benefits, such as extra amenity space and aesthetics induce owners and developers to build green roofs.

Several Canadian municipalities are interested in implementing policies and incentives that would help to collect more green roof benefits on a broader scale, a trend that is closely related to the increased interest in sustainable building practices. Unfortunately, collective benefits cannot be encouraged through sporadic private interests. Relatively large continuous areas of green rooftops are needed in order to provide an effect. It is important for all three levels of government in Canada to revise current policy and introduce new policy to encourage for more extensive green roof implementation.

Although green roof policy is in its infancy in Canada, research like that of the Toronto Green Roof Task Force provides encouraging motivation through its Demonstration Project. The Task Force has determined that if 6% of the total roof area in Toronto (i.e. 6.5 million m²) were greened, these environmental benefits, among others, could be expected (Gutteridge, 2003):

- reduction in urban heat island effect of 1 to 2ºC;
- annual green house gas emission reductions of 1.56 Mega tonnes (MT) direct from buildings and 0.62 MT indirectly from urban heat island reduction;
- reduction in the incidence of "SMOG Advisories" - 5 to10%/yr;
- amount of particulate matter captured by plants - 30 Tonnes/yr;
- stormwater retention capability - over 3.6 million cubic meters/yr; and

- potential recreational space, public and private - 650,000 m².

Directives for green roof practices appear to be growing in Canada. Natural Resources Canada now offers 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.

> *"We would do well to take note of the European experience and to adopt similar corrective programs to improve the environment of our cities."*
> (Osmundson, 1999)

In Germany, the dramatic increase in green roof construction can be attributed to legislation that is linked to collective benefits. The experience in Germany has shown that it is not sufficient to rely solely on the goodwill of the building owners, but rather that it is necessary for the governing authorities to introduce green roof policy (Landskron, 1998). The total area of flat roofs built in Germany in 1997 was 90 million m². The areas of green roofs built annually were approximately 0.6 million m² in 1983, 8 million m² in 1993, and 11 million m² in 1997. Of these green roofs, about 80% were extensive (Hämmerle, 1998). In 2001, the figure had grown to 13.5 million m² (Mann, 2002a).

2.2 Some Findings from German Surveys

Several figures have been proposed in the literature regarding the number of municipalities in Germany with green roof policy. I have included some findings from German surveys, however, it should be noted that there are limitations inherent in these numbers. Given the lack of uniformity of specific building laws and related policies among approximately 14000 municipalities in Germany, it is difficult to provide a comprehensive picture of all the different types of green roof policy. Federal laws provide a general framework for green roof policy without directly supporting it. Keeping a list of German green roof policy current is very difficult, as municipalities are continually added and policies are changed. In the following surveys, there are municipalities that have policy but did not respond to the survey questionnaires. Some cities have more than one type of policy which is why the numbers according to type of policy don't necessarily add up to the total number of cities with policy.

In 1994, the German *Öko-Test-Magazins* conducted a survey of subsidies for garden-related activities (Sabersky, 1994). Although the survey is relatively old, its interesting feature is that it indicates a broad range of green activities that can receive financial support in Germany. The survey asked 186 cities (23 did not respond) with a population over 50,000 to respond with yes or no as to whether they offered subsidies for various ecological gardening components. Some of these components are: systems for reusing water; removing impervious surfaces; building green roofs; green facades; trees; wildflower meadows; shrubs and hedges; biotopes; bird houses; compost bins; peat alternatives; composting; pergola and flower planters; free garden planning advice; free garden design advice; tree pruning school; soil testing for toxic chemicals; and testing in fruits and vegetables for toxic chemicals. Forty-eight cities said they had green roof subsidies.

A list of cities with policy incentives for green roofs in Germany compiled by the green roof company, Optigrün, in 2002, listed a total of 103. Of these 51 cities had direct incentives, 29 had indirect incentives, 35 used green roofs as a mitigation measure for nature conservation, and 28 had green roofs requirements in local development plans.

According to Krupka (2001), 100 German cities have incentive programs with direct financial subsidies ranging between 5 and 60 €/m²

($8-100 Cdn). About 25 cities in the state of North Rhine Westphalia encourage green roofs with direct or indirect financial subsidies, reduced runoff fees, recognition as compensation measure according to the Federal Nature Conservation Act and requirements in local development plans.

Another source of numbers comes from Stefan Zeller's diploma research (2002). He distributed questionnaires to 1,988 municipalities asking about green roof policies and performance rating systems. He received responses from 355 municipalities, of which,

- 44 had green roof incentives in place, 30 had direct financial incentives and 11 had indirect financial incentives, 3 had both, 19 were working on or discussing incentives for green roofs;
- 161 had green roofs integrated in development regulations and 70 followed up with an inspection;
- 29 had a performance rating system (24 different kinds of rating systems were mentioned); and
- 73 said that public buildings were greened.

The most recent survey was completed by the FBB (*Fachvereinigung Bauwerksbegrünung e.V*), the main green roof association in Germany, in January, 2004. Municipalities with a population of over 10,000 were contacted and asked to complete a questionnaire. Out of the 1,488 cities, 398 (27%) responded. Examination of the list, however, reveals immediate gaps as many cities are not represented despite having green roof policies. The results showed that 70 offer direct financial aid, 201 offer stormwater fee discounts, and 145 have green roof requirements fixed in local development plans. The subsidies are often over 10 €/m² ($16 Cdn) to a stipulated maximum amount. In municipalities with split wastewater fees, green roofs typically earn a discount of between 50 and 100% on the annual stormwater fee. That is an average saving of 0.50 €/m² ($0.80 Cdn) each year for a green roof compared to a conventional roof.

2.3 Legal Framework for Green Roof Policy

I have included a discussion of the legal framework to help put the policies into context. The literature on German green roof policy always includes reference to corresponding higher laws, especially federal legislation. These laws are important to making green roof policy widespread and consistent across Germany. Although the laws are not exactly applicable to the Canadian situation, they can provide ideas for revising laws to support green roof policy.

At the global level, the 1992 UN Earth Summit in Rio de Janeiro was the catalyst for "Local Agenda 21", a popular program in Europe in which local authorities implement strategies for sustainable development. European Union directives, such as the Flora-Fauna-Habitat Directive, the Bird Protection Directive and the Water Framework Directive increasingly influence federal laws and in turn green roof policy. More specific regulations for green roofs come from the legislation of the 16 federal German states and subordinate authorities.

The citation method used for this report is as follows: German abbreviation of the statute, § for the section, subsection in parentheses and sentences without parentheses. E.g. *BauGb §1 (5) 7.* English translation of the federal laws is taken from the '*German Law in English*

Language' website (Dannemann, 2004). Note that the translations may be outdated and that German original is always authoritative. With respect to German terminology, land-use plan (*Bauleitplan*) is the generic term for land utilisation plan (*Flächennutzungsplan*) and development plan (*Bebauungsplan*), the latter two being instruments of the first.

I provide a selection of some of the important federal legislation that provides a framework for green roof policy. These are the Federal Building Code, the Federal Nature Conservation Act, the Environmental Impacts Assessment Act, the Land-Use Regulation and the Wastewater Charges Act. Other forms of legislation, such as global, European Union or local, also affect German green roof policy, but they will be mentioned only briefly in this report.

Federal Building Code - Baugesetzbuch (*BauGB*)

From well-ordered to sustainable urban development

> *BauGb §1 (5) Land-use plans shall safeguard sustainable urban development and a socially equitable utilisation of land for the general good of the community, and shall contribute to securing a more humane environment and to protecting and developing the basic conditions for natural life. In the preparation of land-use plans, attention is to be paid in particular to the following:*
>
> *…*
>
> *BauGb §1 (5) 7. the requirements of environmental protection pursuant to section 1a and through the use of renewable energy sources, nature protection and the preservation of the countryside [Landschaftspflege], in particular of the ecological balance in nature, and of water, the air, the ground including its mineral deposits, and the climate, …*

The essential basis for building law is the Federal Building Code. An important subsection, *BauGb §1 (5),* was updated in 1998. In the new version, the term "well-ordered" was replaced with "sustainable" (Roller, 2000) implying responsibility towards future generations. The driver was the 1992 Earth Summit in Rio de Janeiro. In *BauGb §1 (5*) 7., attention is brought to protecting water resources, among other things. An important aspect of groundwater protection is minimizing impervious surface in order to allow stormwater infiltration. The Federal Building Code thus sets one of the legal bases for stormwater source control.

Local authorities specify their own local land-use regulations

> *BauGb §2 (1) The adoption of land-use plans falls within the responsibility of the relevant municipality. Public notice of the resolution on the preparation of a land-use plan is to be made in the manner customary in the municipality.*
>
> *…*
>
> *BauGb §10 (1) The municipality adopts the binding land-use plan as a statute.*

The local authorities are free to "customize" the building code as long as the goals and framework of the Federal Building Code are maintained. The municipality adopts the legally binding land-use plan as a statute.

Compensation measures for interventions

BauGb §1a Consideration for Environmental Concerns

(1) Land shall be used sparingly and with due consideration; the extent to which it is sealed by development shall be kept to a minimum.

(2) In the course of the weighing process pursuant to Section 1 para. 6, the following matters shall be considered:

1. the content of landscape and other plans, in particular those produced under water, waste and pollution control legislation.

2. the avoidance of, and counterbalances for, the impact expected to be suffered by nature and the landscape (provisions of the Federal Nature Conservation Act on intrusions),

3. assessment of the calculated and described impact of a development project on the environment corresponding to the respective stage of planning (environmental impact assessment), to the extent that the admissibility under building and planning law of specific development projects within the sense of the appendix to Section 3 of the Environmental Impact Assessment Act is to be established by reference to environmental impact assessment, and

4. the preservation aims and the purpose of protection for areas of Community importance and of European bird sanctuaries within the meaning of the Federal Nature Conservation Act; in cases where these may be seriously impaired, the provisions of the Federal Nature Conservation Act on the permissibility or execution of such intrusions and the requirement to obtain an opinion from the Commission shall be applied (assessment according to the Flora-Fauna-Habitat Directive)

(3) Counterbalances for the impact to be expected on nature and on the landscape as a consequence of intrusions is set out in the form of appropriate representations as spaces for counterbalances pursuant to Section 5 and as designations as spaces for counterbalances and counterbalancing measures pursuant to Section 9. The representations and designations required under sentence 1 may also be made in respect of some other location than that at which the intrusion takes place provided that this is compatible with ordered urban development and the aims of regional planning, of nature protection and of conservation of the countryside. In place of the representations and designations called for in sentence 1 or sentence 2, contractual agreements pursuant to Section 11 may be entered into or other suitable measures taken to provide counterbalances on land made available by the municipality. Counterbalancing measures are not required in the case of an intrusion which was carried out or was permissible prior to a planning decision being taken.

This section of the Federal Building Code, along with parts of the Federal Nature Conservation Act, forms the basis for the Intervention Rule described in section 3.3 of this report. In essence interventions (intrusions) on nature or the landscape require compensation measures (counterbalances). Green roofs are recognized as compensation measures in many jurisdictions.

Designations for green roofs

BauGb §9 (1) The legally binding land-use plan may on urban-planning grounds make designations regarding:

…

BauGb §9 (1) 25. in respect of individual spaces or of areas covered by a binding land-use plan or parts thereof, and of parts of physical structures, excluding spaces given over to agricultural use or for woodland

a) planting of trees, shrubs and greenery of any other kind,

b) obligations relating to planting and to the preservation of trees, shrubs and greenery of any other kind and of water bodies;

A specific reference to green roofs is in this sentence, where "greenery of any other kind" and "parts of physical structures" refers primarily to green roofs or green façades (Dürr, 1995). It also implies that green roofs fixed into land-use plans must have minimum requirements.

Exceptions for interventions in built-up areas

BauGb §34 The Permissibility of Development Projects within Built-Up Areas

(1) Within built-up areas a development project is only permissible where, in terms of the type and scale of use for building, the coverage type and the plot area to be built on, the building proposal blends with the characteristic features of its immediate environment and the provision of local public infrastructure has been secured. The requirements of healthy living and working conditions must be satisfied; the overall appearance of the locality may not be impaired.

This part of the law permits areas with high density and no nature to be excluded from the Intervention Rule.

Federal Nature Conservation Act - Bundesnaturschutzgesetz (*BNatSchG*)

BNatSchG §1 Purposes of Conservation of Nature and of Landscapes

(1) The conservation, preservation and development of nature and landscapes, both in populated and non-populated areas, shall be such as to effectively serve the following purposes:

1. to maintain the efficiency of the balance of nature,

2. to preserve the exploitability of nature's resources,

3. to conserve fauna and flora, and

4. to safeguard the variety, particularity and beauty of nature and landscapes,

as a basis for mankind's existence and as a prerequisite to recreation in nature and in landscapes.

(2) The requirements resulting from para. 1 shall be weighed one against the other, as well as against other demands of the community on nature and landscapes.

BNatSchG §2 Principles of Conservation of Nature and of Landscapes

(1) The pursuit of the objectives and of conservation of nature and of landscapes shall be guided, where necessary, possible and appropriate, considering all the requirements under Article 1, para. 2, mainly by the following principles:

1. The efficiency of the balance of nature shall be maintained and improved. Anything that adversely affects this balance shall be avoided or compensated for.

2. Non-built-up areas of a size adequate for them to fulfil their purpose shall be preserved, both in general and in particular, since the conservation of these areas is a prerequisite to maintaining the balance of nature, utilising nature's resources and finding recreation in nature and landscapes. Special efforts shall be made to protect, preserve and develop parts of nature and of landscapes, including green areas and their fauna and flora populations, in built-up areas.

3. Economical use shall be made of those resources of nature which are not renewable. Consumption of renewable resources shall be controlled in such a way as to ensure their continued and lasting availability.

4. The soil shall be preserved; any loss of its natural fertility shall be avoided.

5. Any destruction of parts or components of landscapes in the course of mining for natural resources shall be avoided. Lasting damage to the balance of nature shall be prevented. Any adverse effects on nature and landscapes which inevitably result from the exploration and extraction of natural resources and from soil deposits shall be compensated for by recreating the original landscape or by relandscaping areas modelled after nature.

6. Water areas shall also be conserved and increased in size within the framework of nature and landscape conservation efforts. Waters shall be protected against pollution, and their natural self-cleaning properties shall be preserved or restituted. Where possible, systematic development of watercourses from a purely technical point of view shall be avoided, to be replaced by biological water engineering methods.

7. Efforts made within the framework of nature and landscape conservation shall also be aimed at keeping air pollution and noise levels to a minimum.

8. Adverse effects on the climate, in particular the local climate, shall be prevented. Where such effects are inevitable, they shall be compensated for, or reduced, by landscape conservation efforts.

9. Proper use of vegetation shall be ensured. This shall apply in particular to forests, other areas fully covered with plants and vegetation on river banks and lake shores; where vegetation covers are removed in non-populated areas, they shall be replaced by new vegetation that fits in with the local environment.

10. The natural and historically grown variety of wild fauna and flora, as well as their biocenoses, shall be conserved since they are a part of the balance of nature. Their habitats and biotopes, as well as their other living conditions shall be conserved, preserved, developed and restituted.

11. Suitable areas in sufficiently large numbers designated as a function of their location and their natural conditions as areas to be used for short-term recreation by city dwellers living in the vicinity, or as holiday resorts for longer-term recreation, or for other leisure pursuits, shall be developed, appropriately designed and preserved.

12. Access shall be facilitated for the population to parts of landscapes which, by their nature, are particularly suitable for recreational purposes.

13. Historically important cultivated landscapes, or parts of such landscapes, characterised by their singularity shall be preserved. This shall also apply to areas surrounding cultivated landscapes, man-made or natural monuments which are under protection or worthy of protection, where this is required in order to preserve the singularity and the beauty of the monuments concerned.

…

BNatSchG §8 Interventions in Nature and Landscapes

(1) Interventions in nature and in landscapes, as defined in this Act, shall be any changes affecting the appearance or use of areas which lead to considerable or lasting impairment of the efficiency of the balance of nature or of the natural scenery.

(2) The intervener shall be obliged to omit any avoidable impairment of nature and of landscapes, and to compensate for any inevitable impairment, within a period to be specified, by nature and landscape conservation measures, where such measures are required in order to attain the objectives of nature and landscape conservation. The prerequisite to any such obligation shall be that other legal provisions stipulate that the interventions involved shall be subject to authorisation, permission, permits, consent, plan approval, other decisions by, or notification of, competent authorities. Whether a given intervention is subject to the above obligation or not shall be determined by the authority in charge of giving approval or receiving notification. An intervention shall be deemed compensated for if, after its completion, there is no considerable or lasting impairment of the balance of nature, and if the previous landscape has been restituted or if relandscaping measures have been carried out.

(3) In cases where such interventions involve inevitable impairment, or impairment which cannot sufficiently be compensated for, and where the interests of nature and landscape conservation are ruled, upon consideration of all other demands made on nature and landscapes, to take precedence over such demands, these interventions shall be prohibited.

(4) In cases where interventions in nature and landscapes are to be carried out on the basis of specialist plans in accordance with public law, the planning bodies concerned shall describe in detail, by means of written explanations and maps incorporated in specialist plans, all nature and landscape conservation measures required to compensate for the interventions envisaged.

(5) In cases where legal provisions do not stipulate stronger participatory rights for the authorities in charge of nature and landscape conservation, or where the decisions involved are taken by these authorities themselves, the planning bodies concerned shall consult with the authorities in charge before taking decisions or adopting measures. This shall not apply to decisions based on development plans.

…

(10) If the intervention is a project subject to an assessment of its environmental impact in line with Article 3 of the Act on the Assessment of Environmental Impacts, the project must fulfil the requirements of the said Act in that decisions must be made under para. 2 sentence 1, para. 3 or the provisions of para. 9.

The Federal Nature Conservation Act attempts to maintain nature's function and resources in the broadest sense. It limits and regulates construction on undeveloped land using the Intervention Rule. Each state has its own nature conservation act which further defines the federal one. The Intervention Rule is largely based on *BNatSchG §8* and *BauGb §1a*. It is described in section 3.3 of this report.

Environmental Impacts Assessment Act - Gesetz über die Umweltverträglichkeitsprüfung (*UVPG*)

> *UVPG §2 (1) The environmental impact assessment represents an integral part of procedures applied by authorities when deciding upon the approval of projects. Environmental impact assessment comprises identification, description and assessment of a project's effects on*
>
> *1. human beings, animals and plants, soil, water, air, climate and landscape, including the individual interaction that may occur,*
>
> *2. cultural goods and other material assets.*
>
> *Environmental impact assessments are conducted with the involvement of the public. If approval of the project is decided upon by several procedures, the individual assessments carried out in these procedures are compiled to provide an overall assessment of all environmental impacts, including interactions.*

The Environmental Impact Assessment is a tool used during the planning process of a project which determines the probable impact on the environment of a particular project. The result of the assessment is an expert evaluation of the environmental compatibility of a project. While the assessment does not decide whether a project will be built or not, it is considered in the development approval process. The federal law is further defined by state environmental impacts assessment laws.

Land-Use Regulation - Baunutzungsverordnung (*BauNVO*)

The Land-Use Regulation contains regulations on the type and size of built structures on a site, in particular the type of construction and the positioning of buildings on the site (Fabry, 2002)

Wastewater Charges Act - Abwasserabgabengesetz (*AbwAG*)

> *AbwAG §13 (1) The revenue accruing from waste water charges shall only be used for specific purposes connected with measures for maintaining or improving water quality. …*

The Wastewater Charges Act requires that a charge be paid on discharging wastewater into a body of water. It is levied by the federal states. It adheres to the 'polluter pays' principle and achieves two purposes:

- it serves as an incentive to stop avoidable pollution from entering the waterway,
- and it provides a fund for environmental protection and improvement.

The tax is levied on municipalities, wastewater associations, industrial, commercial and agricultural businesses. Municipalities are responsible for the tax by "small connectors", those who contribute less than 8 cubic meters of sanitary sewer to the system. The amount of tax is based on the pollution load. Damage units are calculated and there is a fee per damage unit (e.g. 35.79 €/unit ($57 Cdn) in North Rhine Westphalia). As an incentive, reductions of 50% may be applicable if the wastewater is treated according to state-of-the-art techniques before being discharged.

A portion of the revenue in North Rhine Westphalia is used to fund a state program which subsidizes the implementation of stormwater source controls, including green roofs (see sections 3.2 and 4.1).

3 Types of Policy

3.1 Direct Financial Incentives

In Germany, direct financial incentives customarily take the form of subsidies available to property owners and developers who build green roofs. These subsidies vary considerably in their purpose and design; therefore it is necessary to examine specific examples. They are usually implemented at the municipal and community levels. The two exceptions are the states of North Rhine Westphalia and Bremen; however, even these are administered by municipal governments.

The amount of subsidy is usually determined in two ways, the most common being a specified sum per square meter. As determined by the survey conducted by the FBB in 2004, subsidies range from about 10-30 €/m² ($16-48 Cdn). Another method of arriving at the amount of subsidy is by calculating the percentage of costs of construction or construction and design. Frequently between 10 and 50% is covered. Although most programs have a ceiling amount, it can vary greatly. In addition to financial support, these programs may also provide design and technical advice.

Most of the subsidies are subject to conditions. Common conditions are minimum runoff coefficients (usually ≤ 0.3), minimum substrate thickness (varies), and minimum duration of maintenance (usually 10 years). Less common conditions are no connection to the combined sewer system, maximum roof slope, PVC-free waterproof membrane, ecologically valuable vegetation community with minimum height of growth, and subsidies not permitted if green roofs were required in the development plan.

One of the more generous subsidy programs is the “Initiative for Ecological and Sustainable Water Management” in North Rhine Westphalia which has improving water quality as its main purpose. It is discussed in detail in section 4.1. Similarly, the city state of Bremen subsidizes 25% of the costs of roof greening to a maximum of 1,500 € ($2,400 Cdn) (Bremer Umweltberatung, 2004). Their aim is stormwater source control, with green roofs providing water retention and reduced loads on the sewer system and water treatment facilities.

Sometimes direct financial incentive programs target priority areas of a city, such as those lacking in green space. An example is downtown Munich where greened retrofitted roofs qualify for a subsidy of 30 €/m² ($48 Cdn) to a maximum of 50% of the cost (Landskron, 1998).

One of the older subsidy programs was implemented in Berlin between 1983 and 1996. The Courtyard Greening Program was designed to encourage greening of courtyards, as well as the roofs and walls associated with them. The aim was to improve urban climate, quality of life for residents, and the urban appearance. On average each square meter was subsidized with 19.10 € ($30.56 Cdn) which included separate amounts for construction and design. During the period of the program, 54 ha of courtyard and roofs were greened and 32.5 ha of facades were greened. This translated into subsidies worth 16.5 million € ($26.4 million Cdn) (Schmidt, 2000).

Opportunities

- As an incentive, property owners are not forced to include green roofs; they act voluntarily when there are clear economic gains.
- Direct financial incentives can be designed to suit any number of purposes that the jurisdiction has.
- Incentive programs are useful to encourage green roofs in specific target areas, such as existing built-up areas and densely developed areas, where regulation is difficult to impose.
- Direct financial incentives are effective for retrofit roofs.
- The incentive per square metre is proportional to the overall environmental benefit.

Limitations

- Municipalities can run out of the funds needed to pay for financial incentives, effectively terminating such programs. Berlin had direct financial incentives, such as the Courtyard Greening Program, but has had serious budget cutbacks. It is now investing on a strict minimum of scattered projects (Reichmann, 2003).
- Some jurisdictions have extremely limited budgets and more pressing priorities to begin with. Noteworthy is the fact that there are few direct incentive programs in the former East Germany, where a large proportion of capital is being directed toward basic infrastructure work.

3.2 Indirect Financial Incentives through Split Wastewater Fees

Indirect financial incentives usually involve split wastewater fees. Split wastewater fees specifically relate to the “user-pay” for stormwater disposal, unlike direct financial incentives which are not as specific.

The traditional fee system uses fees collected from water consumption rates to pay for both sanitary and stormwater disposal. With split wastewater fees, the property owner pays both a sanitary disposal fee based on water consumption and an annual stormwater fee based on the area of impervious surface on the property. Stormwater source controls such as green roofs may earn a discount depending on the municipal regulations. An owner who is disconnected from the public sewer system may be completely exempt from stormwater fees.

Split wastewater fees have economic and environmental benefits. By encouraging stormwater source control, they reduce site-level runoff by reducing the runoff volume and peak flows entering the public sewer system. Reduced loading can mean smaller pipe sizes, smaller water treatment facilities, fewer overflows leading to pollution of adjacent bodies of water, and improved flood control. Stormwater fees make the cost of managing stormwater more transparent. They discourage construction of impervious surfaces and encourage source control by offering discounts.

Moreover, split wastewater fees are more fair from a social perspective. Because the conventional fee system is based on water consumption, large families in multi-family residences, in effect, finance stormwater disposal. This is unjust because they own very little land and therefore do not contribute much stormwater runoff, yet because of their large numbers, they consume more water. Results of a study by the Ratepayers Association (*Bund der Steuerzahler*) of North Rhine Westphalia support this idea. The study evaluated the split wastewater fee system over the years 2000 and 2001. In 2001, 49.6% of municipalities in the state had split wastewater fees. They calculated the fees before and after split wastewater fees were introduced for an average four-person household with a water consumption rate of 200 m³ and 130 m² of impervious surface. The results showed that there was an overall rate increase of 1.8% (still below the inflation rate of 2.8%). A family of six in a multi-family residence with only 50 m² of impervious surface would be able to save 17.8% in taxes under the split wastewater system (Hennebrüder, 2003).

Using the results of the above study, BUND, the German branch of *Friends of the Earth*, calculated that the average four person household could save approximately 17% in taxes if it were to remove the impervious surface associated with their residence (Hennebrüder, 2003).

BUND has been leading the change towards split wastewater fees. Armed with environmental, economic and social justification, they have launched court battles against various jurisdictions. Several courts in various states have ruled in favour of split wastewater fees. For example, on 09.10.1995 the Schleswig-Holstein administrative court ruled that (Fabry, 2003):

> *1. The calculation of fees for stormwater discharge based on built or impervious surface is an approximate measure with the closest accuracy.*
>
> *2. A legal allowance for green roofs for the draining of stormwater in the amount of 50% is appropriate and does not contradict §3 (1) GG.*

Another example comes from the administrative court ruling in Hessen on 07.06.1985 (Fabry, 2002).

> *The charging of split fees for the discharge of sanitary sewage calculated according to water consumption rates and for the discharge of stormwater calculated according to built and impervious square meter surfaces of the property, allows the by-law from hereon in a substantially better adjustment of the fee rate to the actual proportion, as would be the case of charging the singular fee for sanitary and stormwater discharge measured according to water consumption.*

The FBB 2004 survey found that 201 out of the 398 municipalities that responded to the survey had split wastewater fees. The discount on the stormwater fee varies from 0-100% with the most common discount being 50%. Some have a range of discounts that depend on the thickness of the substrate. Those with a 100% discount may have a condition that the roof not be connected to the public sewer system. Another condition is a maximum runoff coefficient, usually of 0.3. The annual stormwater fees vary considerably from as low as 0.20 €/m² ($0.32 Cdn) to more than 2.00 €/m² ($3.20 Cdn). Some examples are Dortmund with 0.80 €/m² ($1.28 Cdn) and Dresden with 1.15 €/m² ($1.84 Cdn). In any case, the impervious area adds up quickly and property owners are correspondingly motivated to reduce the annual fee. In a study conducted in North Rhine Westphalia of municipalities with stormwater fees, extensive green roofs were found to be clearly less expensive than gravel roofs over a 40 year period whereas in municipalities without stormwater fees, the difference in cost was insignificant (Krupka, 2001).

Stormwater fee discounts and the runoff coefficients of roof surfaces are loosely related: generally the higher the coefficient, the higher the fee. An impervious roof does not qualify for a discount. A typical extensive green roof has an approximate runoff coefficient of 0.5 and qualifies for a 50% discount. A green roof that retains sufficient amounts of water, usually in conjunction with other source controls like trenches, swales or cisterns, and that does not connect to the sewer system, is normally exempt from the fee.

Table 1, produced by the FLL (2002), shows the runoff coefficient for green roofs according to thickness.

Table 1: Runoff coefficients (C) according to green roof thickness and slope. Source: FLL (2002)

	Roof slope up to 15°	Roof slope over 15°
>50 cm thickness	C=0.1	-
>25-50 cm thickness	C=0.2	-
>15-25 cm thickness	C=0.3	-
>10-15 cm thickness	C=0.4	C=0.5
>6-10 cm thickness	C=0.5	C=0.6
>4-6 cm thickness	C=0.6	C=0.7
>2-4 cm thickness	C=0.7	C=0.8

These coefficients are based on a rainfall event of 300l/(s x ha) on a previously saturated roof left to drain for 24 hours.

Table 2, also produced by the FLL (2002), shows average annual water retention capacity and the annual runoff coefficient/permeability factor according to thickness.

Table 2: Reference values for the annual water retention percentages of green roofs according to thickness. Source: FLL (2002)

Type of greening	Thickness in cm	Form of vegetation	Average annual water retention in %	Annual runoff coefficient/ permeability factor
Extensive	2-4	Moss-sedum	40	0.60
	>4-6	Sedum-moss	45	0.55
	>6-10	Sedum-moss-herb	50	0.50
	>10-15	Sedum-herb-grass	55	0.45
	>15-20	Grass-herb	60	0.40
Intensive	15-25	Lawn-perennial-small shrub	60	0.40
	>25-50	Lawn-perennial-shrub	70	0.30
	>50	Lawn-perennial-shrub-tree	>90	0.10

These values are based on a location with 650-800 mm of annual precipitation and multi-year records. In regions with less precipitation, the retention capacity is higher and in regions with higher precipitation, it is lower.

Not only is the water retention capacity of a green roof important for stormwater management but also the water quality of the flow-through should be taken into consideration. The quality of water coming off a planted roof, which is generally very good because the water is filtered through vegetation and planting medium, is suitable for stormwater systems and other forms of source control without pre-treatment. To achieve higher efficiency and sustainability, roof water can be re-used for household washing, toilet flushing, and potentially human consumption. The water quality is affected in large part by the materials used in the planting medium. Organic content should be kept to a minimum to restrict nitrogen levels. The FLL guidelines recommend less than 12% mass of organic content for intensive green roofs, less than 8% for multi-layer extensive green roofs and less that 4% for single-layer extensive green roofs. Studies in Veitshöchheim are looking at the effectiveness of amendments like activated carbon, clay and zeolite (a volcanic substance) to filter water on green roofs and improve water clarity making it more suitable for certain applications such as washing and toilet flushing (Marx, 2002). The quality of water running off green roofs on a new administrative building in Wiesbaden was tested and found to meet regulations for drinking water. The planting medium of these single-layer extensive roofs contained no organic material and was amended with zeolite (Ngan, 2004).

In Canada, the funding of sewerage infrastructure is similar to the former German system in that it is insensitive to user loads. An obstacle to sustainable infrastructure is sunken investments which Moffat (2001) describes as follows: "The very substantial capital outlays that have been dedicated to existing infrastructure can eliminate the potential for cost savings from Green infrastructure. Sometimes property taxes are already predicated on paying for larger, centralised systems, and thus anyone who invests more money to reduce reliance upon such systems ends up paying twice."

Opportunities

- Stormwater fees provide a strong basis for integrated stormwater management with the aim of protecting water resources.
- Split wastewater fees are considered an efficient and successful form of incentive for green roofs (FBB, 2003). Reichmann (2003) claims it is the most important incentive in Berlin. My observations gathered while working in Germany lead me to think that the split wastewater fee incentive is currently the preferred type of green roof policy.
- The annual revenue from stormwater fees may be attractive to municipalities struggling to pay for sewerage infrastructure maintenance and operations.
- Incentives may work better than mandating green roofs through regulations or other means since property owners act voluntarily when there are clear economic gains.
- The policy could run indefinitely, unlike direct financial incentives which depend on municipal budgets.
- It is easy to communicate to citizens because it introduces fairness and transparency.
- This policy works well in both new development areas and in existing ones.
- Compared to subsidies which are usually a one-time financial advantage, annual stormwater fees are a more permanent incentive and therefore long-term maintenance may be more enforceable.
- Source control might be the only way to develop in areas where the sewerage infrastructure is already filled to capacity.
- Portland, Oregon is moving towards a similar system where green roofs would earn discounts for stormwater disposal. The effectiveness of the Portland initiative is worth monitoring.

Limitations

- Some municipalities, mostly small ones, complain about the cost of administering split wastewater fees. It is worth noting that the Berlin water authority claims that the change to a split system had a neutral effect on their profitability (BWB, 2004).
- Municipalities may be tempted to off-load responsibility for stormwater disposal to the private owner.

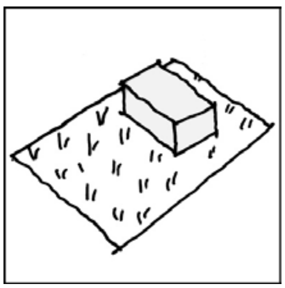
- A system for inspection and maintenance may be required to ensure proper and continuing stormwater retention function.
- There may be opposition to stormwater fees from the sewer manufacturing industry.

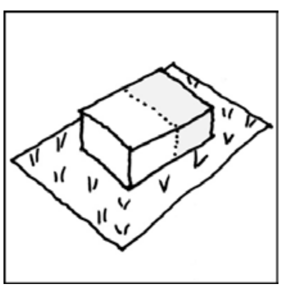
3.3 Ecological Compensation Measure

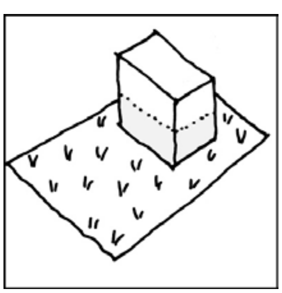
> *"The nature, which we have on our roofs, is a piece of earth that we have killed so that we could build a house on the spot."*
> F. Hundertwasser

The adjacent quotation by the architect and urban designer Friedensreich Hundertwasser (Linz, 2000) neatly sums up the idea of using green roofs as a compensation measure for interventions in nature. The basis for ecological compensation measures is that 70 ha of land are being built over every day in Germany and the landscape requires compensation for this loss (FBB, 1997).

The policy centres itself around the German "Intervention Rule." The Intervention Rule is based on sections from the Federal Building Code, the Federal Nature Conservation Act, and the Environmental Impacts Assessment Act. The Intervention Rule is a decision-making process that is applied at the land-use and development level.


Existing condition


Proposed extension

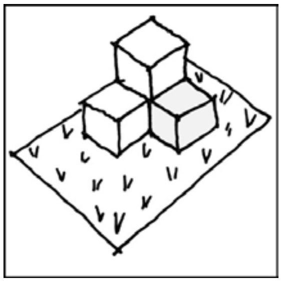

Avoidance

As a first step, it is necessary to determine if a proposed project is an intervention in nature or the natural scenery. An intervention is defined in *BNatSchG §8 (1)* as "*any changes affecting the appearance or use of areas which lead to considerable or lasting impairment of the efficiency of the balance of nature or of the natural scenery*." The municipality is responsible for classifying interventions in their land-use and development plans (Landskron, 1998). In consultation with the overriding environmental protection agency, the municipality is also responsible for integrating the Intervention Rule into the local project approval process by making appropriate decisions about avoidance, minimization, compensation and replacement (SenStadtUm, 2004a). An intervention can be a number of things, but typically it is buildings, paved surfaces, grading changes, changes to the drainage pattern, etc. The areas that are affected by the Intervention Rule are not "nature reserves," as these would be more strictly protected, but typically vegetated areas on the edge or within urban areas. The issue is whether they serve natural functions such as infiltrating stormwater, providing habitat for plants and animals, preserving soil resources, contributing to better air quality, etc., in addition to whether they contribute to the landscape scenery. The latter may include such things as optical, acoustical and olfactory impressions regardless of whether they are new or historical, natural or cultural (SenStadtUm, 1999). Areas that are being redeveloped are usually exempt because they already contain interventions.

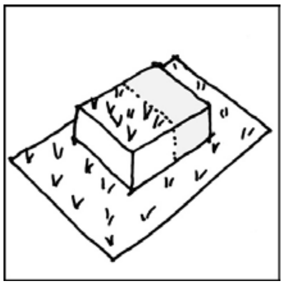
The intervention procedure is as follows. An intervener must answer the following questions in the order provided. If the answer is yes, they are obliged to make the necessary changes.

1. Can the intervention be *avoided*? For example, an owner who wishes to build an extension on his house can avoid making an intervention by adding another storey instead of covering more ground space.

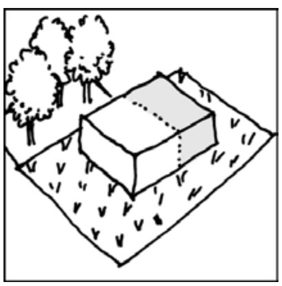
2. If the intervention cannot be avoided, can it be *minimized*? In this case, the same owner who wishes to build an extension can build a compact multi-storey extension on the side of his house instead of a single-storey, spread out extension.



Minimization



Compensation



Replacement

3. If the intervention cannot be minimized, can it be *compensated* for? This is done by implementing a compensation measure which compensates for the lost value of nature by the intervention. It is applied in the same location as the intervention. The municipality decides what will qualify as a compensation measure according to their needs but within the framework laid out by federal law (Dürr, 1995). Selecting compensation measures is a topic for public involvement and discussion and involves consultation with environmental agencies and experts. It is at this stage that green roofs can be recognized as a compensation measure using the instruments set out in *BauGb §9 (1) 25* (Fabry, 2002). Other measures include planting trees and providing green space. Compensation measures are described both in written and graphic form in development documents, such as a landscape conservation accessory plan, by the local planning authority. Once the regulations are set, there is no leeway for a property owner to propose another type of compensation measure. In other words, an owner cannot choose green roofs unless the municipality has agreed to recognize them.

4. If the intervention cannot be compensated for, can the lost value of nature be *replaced*? In this case, a similar form of what was lost is replaced in another location. For example, a park of about the same size as the area that the intervention occupies built a few blocks away might be a suitable replacement measure. If a replacement is not possible, a financial compensation used towards nature conservation is in order or else the project cannot be approved as proposed.

As a compensation measure, green roofs can be integrated into development regulations in two ways. The first way is as a compensation measure pursuant to the Federal (or State) Nature Conservation Act and the second is in within the general framework of the Federal Building Code (see section 3.4). In any case, the question of minimum requirements and an evaluation procedure emerges. When green roofs are required as a compensation measure, the minimum requirements and evaluation procedure are very specific to what the roof is compensating for. The FLL has proposed a performance rating system called the *FLL Bewertung* (1998). It can be used by municipalities as a tool to clearly define green roof systems that would suitably compensate for ecological damage caused by an intervention. See section 3.5 for more information on the FLL performance rating system, as well as the Karlsruhe performance rating system.

Opportunities

- The ecological compensation policy provides a strong basis for protecting nature. Green roofs specifically aim to compensate for natural functions that are lost in the process of developing a site.
- This policy targets specific locations (those areas with nature to lose) rather than building type or roof type for greening which adds another option in the range of policy tools.
- Similar to the polluter-pay principle, this policy requires that the party causing impairment to natural functions is the one to pay for the mitigation or compensation measures required.

Limitations

- Because the purpose of this policy is so specific, maintenance and performance targets over the long-term need to correspond with what is being compensated for. This has been a challenge in the German experience.

- At the federal level, this policy does not specify green roofs. They are recognized as a compensation measure only at the municipal level, making it a rather unevenly distributed policy.

3.4 Integration into Development Regulations

Incentives are desirable forms of policy because of their voluntary nature; however compulsory measures are more effective in some instances. Integrating green roofs into development regulations is another tool available to increase the coverage of green roofs. In their 2004 survey, the FBB found that 145 of the responding municipalities had green roofs anchored in their development regulations. The green roof benefits that the regulations target can vary considerably: minimizing impervious surface, improving water quality, ameliorating urban climate, ecological compensation, aesthetics and amenity space. Often the regulations are combined with an incentive program (FBB, 2003)

Local authorities may include green roofs in their development regulations based either on ecological compensation measures (see section 3.3) or based on the Federal Building Code. The most specific basis is in *BauGb §9 (1) 25*, in which designations for green roofs are permitted in legally-binding land-use plans. Density bonus regulations (green roofs as compensation for higher density) can be integrated into development plans according to the Land-Use Regulation (Dürr, 1995).

The regulations specify which roofs are to be greened and their minimum requirements. Commonly, flat roofs and roofs with a slope up to a specified degree in a certain neighbourhood are required to be greened. Regulations in some municipalities may require that all public buildings have green roofs to set an example. Locations, such as peripheral areas where a smooth transition to the natural landscape is sought, may require green roofs (Dürr, 1995). The minimum requirements should relate to an analysis of the expected benefits and extra costs involved in building the roof (Fabry, 2002). There may be requirements for substrate depth, water retention target and suitable plant material. Often there is a reference requiring adhesion to the FLL guidelines.

Typically the inclusion of green roofs in development regulations can be worded as follows (Fabry, 2002):

> *The roof surfaces are to be constructed as greened surfaces and over a minimum substrate depth of … and … to be planted so that a continuous vegetation cover is guaranteed which must be permanently maintained.*

Example from Stuttgart, Development Plan 21 – Area A1 (Fabry, 2002):

> *The anchoring of roof greening (80% of the roof surface with minimum 12 cm substrate depth; 20% with minimum 60 cm substrate depth) is required for urban design reasons as compensation for sparse green public space, urban climate optimization and as partial replacement for biotopes. Because of the exposed location of the development area in the Stuttgart basin with good visibility from the surrounding elevations, wide-spread variable roof greening can achieve an optical integration with the encircling green areas (Hanggrün/Schlossgarten).*

Excerpt from a bylaw in Stadt Esslingen am Neckar (FBB, 1997):

2.0 Planting requirements for green roofs:

2.1 Flat roofs and roof surfaces with up to 15º slope are to be extensively greened and permanently maintained. Exceptions are glass roofs, conservatories, terrace overhangs as well as roof surfaces under 10 m².

2.2 The roof greening must have an average root-penetrable thickness of at least 15 cm, of which the thickness of the growing medium must be at least 10 cm on average, so that a permanent and contiguous vegetation surface comprising sedum, grasses and perennials (Sedum-Grass-Perennial greening according to the FLL guidelines, 1995) is guaranteed. Intensive greening is also permissible.

2.3 The roof greening with all its components must have a water retention capacity of at least 35 l/m². The content of organic material in the growing medium shall remain between 3 and 12% of the mass.

…

Opportunities

- Integrating green roofs into development regulations is useful when financial green roof incentives are not possible because of budget constraints.
- Regulations are especially effective in new development areas where all buildings are subject to a development approval process.
- Some German cities require that all flat roofs on public buildings be greened as an example to encourage the private sector.

Limitations

- Some property owners and developers are likely to protest against the extra costs. Although life cycle costs may favour green roofs, developers with short-term investment goals may be unable to recoup their investment. However, they may benefit in ways not initially calculated. Experience gained from Stuttgart has shown that some of those who complained vehemently later proudly presented their new environmental image on company brochures (Landskron, 1998).
- Regulations are difficult to implement in existing areas and for retrofit projects. Often a combination of regulations in new developments and incentives for existing areas are used to promote green roofs in all areas.
- There are some areas where green roofs are not appropriate. For example, green roofs may not be appropriate in areas where visual design consistency, wood shingle roofs for example, is promoted.

3.5 Other Policy Initiatives and Tools

Competitions and Media Coverage

Public awareness is an important tool in encouraging green roofs and should be a part of any green roof initiative. In Mühlheim, where there is an enormous amount of green roof construction, public awareness plays a large role. Rudolf Gix, also known as the "green roofer of Mühlheim," has been very successful in promoting the green roof industry. Competitions, he says, being voluntary initiatives are more positive than regulations which many owners see as a burden. In addition, competitions increase the profile of green roofs in the public eye. This is an important factor because often the roofs are not physically visible or accessible to the public. Competitions and associated media coverage ensure that green roofs are seen and appreciated. The significant number of green roofs in Mühlheim is largely the result of positive media coverage which consistently publishes articles on green roofs (Gix, 2003).

The city of Karlsruhe organizes competitions for greening projects in industrial areas. The competitions encourage attractive designs, including green roofs, in the urban fringe where visitors form their first impressions of the city.

Greening of Public Buildings

The state of North Rhine Westphalia is attempting to set an exemplary model of environmental sensitivity by implementing green roofs on state owned buildings. In a circular by the Ministry for Urban Design, Housing, Culture and Sport from 21.12.1998 under section 3.1.2.3 Building Ecology Aims, it includes in the list, "greening of roofs with a slope of less than 25 degrees with location-appropriate plantings" (Mainz, 2004).

Reducing Ecological Impact

If green roofs are to be proposed as solutions to environmental problems, then it follows that the construction of green roofs should also be as environmentally sound as possible. Green roofs are constructed out of a number of materials, some of which require high amounts of energy to produce (expanded clay and slate), others which must be transported from distant places (lava rock) and others which are not recyclable (plastic drainage mats, filter cloth) (Krupka, 2001). Waterproofing membranes also contain materials (PVC, root repellent chemicals) with negative ecological impact. There is a movement towards reducing the ecological impact of building green roofs. The German Roof Garden Association proposes these "Ecological Guidelines for Roof Greening" (DDV, 2004):

> *Production: Use of recycled materials, consideration of the energy balance for materials, new or recycled.*
>
> *Manufacturing: Reduced environmental impact of manufacturing through resource and energy savings.*
>
> *Transport: Minimizing the transportation distances by building and/or extending a logistics system.*
>
> *Application: Sustainable use of materials through long lifespan (durability).*
>
> *Waste disposal: Disposal safeguard through re-utilisation.*

An area that requires further research is the use of recycled materials for green roof components. One that is used often and successfully in Germany is recycled crushed brick which is suitable for use in growing media and drainage layers. It is easily available in the country so it need not be transported far. Using recycled brick relieves pressure on landfills as well as saving on raw materials (DDV, 2004).

Finding local materials appropriate for green roof construction will be one of the important tasks in developing the green roof industry in Canada. Detailed product-independent specifications like those written by the FLL for the various materials necessary for green roof construction will become very useful.

Performance Rating Systems

One of the main concerns with green roof policy is how to ensure that performance goals are met and continue to be met over the long-term. Performance rating systems are tools used for this purpose. Stefan Zeller has been examining the different types of performance rating systems used in Germany. In his survey of 355 total responses, he found that out of 29 municipalities (8% of responses) that used a standard performance rating system, there were 24 different types used (Zeller, 2002). The most frequently used system (4 responses) was the one developed by the FLL (1998). It appears that many jurisdictions have devised their own system which may be as simple as a verbal agreement. Perhaps even more common is not using any system at all. For reasons of comparison, monitoring, justice and legal conformity, there is motivation to develop a national performance rating system for green roofs (Zeller, 2003).

FLL performance rating system

A key was developed by the FLL (1998) specifically for the rating of green roofs in land-use planning, building permit approvals and construction acceptance. The basis of the rating system is the thickness of the green roof construction penetrable by roots, from which 10 base points per cm are calculated. These points are dependent on the particular roof construction meeting minimum requirements for the following parameters:

- water retention capacity of the growing medium;
- water retention capacity of the drainage layer;
- number of plant species for extensive green roofs; and
- plant biomass for intensive green roofs.

In addition to the above quantitative elements, the FLL system identifies qualitative characteristics according to type of roof construction. These are typically used to judge whether a project is suitable for ecological compensation according to the Federal Nature Conservation Act. Each natural function parameter is deemed either “possible to fulfill completely”, “possible to fulfill partially”, or “slightly or not possible to fulfill.” The qualitative parameters are:

- soil;
- surface water;
- load shedding from the sewer system;
- groundwater recharge;
- purification of stormwater;
- filtering of air;
- oxygen production;
- temperature levelling;
- flora and fauna habitat;
- landscape and urban scenery; and
- people / leisure / healing.

Karlsruhe model in relation to ecological compensation

The model used by the city of Karlsruhe looks at different types of roof greening and rates them according to five natural functions: soil, climate, flora, fauna and water balance. The rating system is used within the framework of the “Intervention Rule.” In other words, it rates how suitable a type of green roof (or other biotope) is for use as an ecological compensation measure. A comparison of performance rating systems by Zeller (2003) found that the Karlsruhe model was the most “well-rounded”. For that reason, I have included Table 3 to show how it works. Note that each model or system differs widely.

Table 3: Karlsruhe performance rating system for green roofs. Source: Henz (2004) (Translated with minor modifications by Goya Ngan)

	3-5 cm growing medium	15 cm growing medium	25 cm growing medium	25 cm growing medium	40 cm growing medium	40 cm growing medium	approx. 1 m growing medium
Soil 15%*	Inorganic substrate, mats, lava, expanded clay, crushed brick, zeolite, etc. **5% ***0.0075	Constructed growing medium from natural soil materials. Nutrient poor. 10%**, 0.015***	Constructed growing medium from natural soil materials. Nutrient poor. 20%**, 0.03***	Constructed growing medium from natural soil materials. Nutrient poor with mounding. 20%**, 0.03***	Constructed growing medium from natural soil materials. Nutrient rich. 30%**, 0.045***	Constructed growing medium from natural soil materials. Nutrient rich. 30%**, 0.045***	Constructed growing medium from natural soil materials. Nutrient rich. 50%**, 0.075***
Climate 15%* (evaporation)	30%**, 0.030***	50%**, 0.075***	60%**, 0.090***	60%**, 0.090***	70%**, 0.105***	70%**, 0.105***	90%**, 0.135***
Flora 30%*	Sedum spp., mosses, few grasses and herbs. Species poor. 10%**, 0.030***	Species rich, dry extensive grass (without Lolium perenne) 100%**, 0.300***	Species rich, dry extensive grass (without Lolium perenne) 100%**, 0.300***	Sedum, grass spp., many herb spp., woody plants. Species rich. 120%**, 0.360***	Relatively species poor, mostly non-native species (ground covers, perennials) 20%**, 0.006***	Shrubs, herbs, high portion of wild species 60%**, 0.18***	Mixture of native and non-native woody plants, small trees, lawn. 50%**, 0.150***
Fauna 30%*	Avian (Flying) flower visitors in May/June. Relatively few, widespread species, no permanent soil organisms because of extreme temperatures. Mobile crawling beetles and spiders (pioneer species) 5%**, 0.015***	Enduring bee and butterfly meadow, possible pauses during drought. Mobile crawling beetles and spiders. Probably permanent new colonisation because of extreme microclimates. Up to now no proof of dry and nutrient poor grass species. Earthworms, sowbugs, millipedes occurring as in compacted urban soil, snails as in rich urban vacant land. 10%**, 0.030***	Enduring bee and butterfly meadow, possible pauses during drought. Mobile crawling beetles and spiders. Somewhat better conditions for soil organisms as with 15 cm. Up to now no proof of dry and nutrient poor grass species. Earthworms, sowbugs, millipedes occurring as in compacted urban soil, snails as in rich urban vacant land. 10%**, 0.030***	Snails dominant. Beetles, spiders, cicadas, all fauna from topsoil, soil species and herb layer species. Largest occurrence of fauna species for green roofs. 20%**, 0.060***	Permanent soil organisms, nest opportunities for birds, protection from sun and wind, spider webs possible. Because of species poor flora, also few fauna species, apart from soil organisms. 10%**, 0.030***	Ants and sowbugs dominant. Few herb layer species. Permanent soil organisms, nest opportunities for birds. 15%**, 0.045***	Permanent soil organisms, nest opportunities for birds, protection from sun and wind, spider webs possible. Somewhat larger species variation with herbs result in larger variation of fauna species. 15%**, 0.045***
Water Balance 10%* (average annual stormwater retention)	45%**, 0.045***	65%**, 0.065***	70%**, 0.070***	70%**, 0.070***	80%**, 0.080***	80%**, 0.080***	100%**, 0.100***
Total value****	**0.14**	**0.48**	**0.53**	**0.60**	**0.32**	**0.45**	**0.50**

** weighting, ** percent function of nature balance achieved, *** percent weight x percent function / 10,000 = subtotal, **** sum of subtotals gives the value*

4 Examples of Existing Policy

4.1 North Rhine Westphalia: Direct Financial Incentives

The Jurisdiction

Landschaftspark, Duisburg

With about 18 million inhabitants, North Rhine Westphalia (NRW) is the most heavily populated state in Germany. NRW includes the intensively industrialized Ruhr area where numerous cites (Essen, Dortmund, Duisburg, Bochum and Gelsenkirchen) merge to form a highly populated unit. The population of the Ruhr area is about 9 million and the population density between Duisburg and Dortmund reaches 1200 people per square kilometre. The Ruhr is a tributary of the Rhine, along which are situated Cologne, Düsseldorf and Bonn. The resources of the state include hard coal, brown coal and iron ore deposits which supplied a productive iron and steel works industry. There was also a thriving chemical industry. For many years the hard coal mining has had to be subsidized because of lower prices in other countries. Brown coal mining has been called into question because of the negative environmental impact. Iron ore mining is no longer supported. These changes have had positive effects on the environment. In parts of the Rhine, the Ruhr and other bodies of water that were made barren by pollution, fish have returned. Air pollution has been greatly reduced. Many previously industrial areas have been converted into parks and recreational areas. In spite of industrial downturns, NRW remains an economically powerful state.

Key Driver

The key driver for this policy is improved water quality. The idea is that stormwater source controls, including green roofs, will reduce stormwater volume and delay stormwater runoff which will result in a reduced load at water treatment plants, disconnection of surfaces from the public sewer system, reduced sewer overflow and flood control.

Description of the Policy

The “Initiative for Ecological and Sustainable Water Management” is a 320 million € ($512 million Cdn) program on state subsidy in several areas of water and wastewater management (Mainz, 2003) The program is developed by the Ministry of Environment, Consumer Protection, Nature Conservation and Agriculture (MUNLV) of NRW. The aim of the program is to conserve and improve the water quality of rivers and bodies of water. Funding for the program is generated from fees imposed on polluters according to the Wastewater Charges Act (see section 2.3). The Act requires that these funds be used only for improving water quality and cannot be mixed into general revenue. Therefore, the subsidies are financed according to the “polluter-pay” principle for wastewater management.

Application of the Policy

The subsidy program is administered by the municipalities through their respective engineering, tax, or environment departments. It may also be administered through municipal waste disposal companies. Information on the program is available through various levels of government and through the internet.

The program consists of several areas eligible for subsidy. In the case of green roofs, it falls under Subsidy Area 6 which includes the following forms of stormwater source control:

- For removal of impervious surfaces: 15 €/m² ($24 Cdn) of removed surface.
- For infiltration systems (source controls): 15 €/m² ($24 Cdn) of newly designed infiltration surfaces. Eligible for subsidy are the required construction and technical measures, such as conduit system or infiltration setup.
- For roof greening: 15 €/m² ($24 Cdn). In terms of roof greening, the insulation and drainage layers, the substrate and the plants are eligible for subsidy. Not eligible is the roof deck.
- For rainwater – up to 1,500 € ($2400 Cdn) per re-use system.

The program targets projects in existing urban areas. Projects in new developments are generally required to implement source control and green roofs in order to be approved so these would not be eligible. Likewise green roofs required as a compensation measure according to the Federal Nature Conservation Act are not eligible for subsidy. The subsidy can be used in combination with the stormwater fee discounts (Stadtentwässerungsbetriebe Köln, 2004).

In the subsidy application form, the applicant enters the size of the green roof, the thickness of the green roof components, portion affected by stormwater runoff delay, the runoff coefficient and whether or not the roof construction load has been structurally confirmed.

Minimum Requirements

The NRW subsidy program requires that the green roof have a runoff coefficient of less than 0.3 as a measure to ensure that the aim of improving water quality is met. There are two ways that this performance goal is checked: by requiring a minimum depth (penetrable by roots) of 15 cm or by requiring proof (i.e. independent certification) that the green roof product has a runoff coefficient of less than 0.3 (Mainz, 2004). Some products can have a thickness of less than 15 cm and still meet the performance goal.

This subsidy program is so important to the industry that the large green roof company, Optigrün, sells a product called "Optigrün-Extensivsubstrat Typ NRW 03" especially developed to meet the requirements of the 0.3 runoff coefficient requirement while maintaining the lowest possible thickness and weight (Optigrün, 2002).

Effectiveness

From the beginning of the program in September 1999 to the end of 2003, the MUNLV Ministry released 12,366,490 € ($19,786,384 Cdn) in grants for green roofs which resulted in the greening of approximately 825,000 m² roofs (Mainz, 2004). When the green roof areas are added to the removal of impervious surface and installation of stormwater source controls, about 59 million € ($95 million Cdn) were given out which translates into about 6 million m² of runoff-effective surfaces that could be disconnected from the public sewer system.

4.2 Cologne: Indirect Financial Incentives through Stormwater Fees

The Jurisdiction

Cologne, a city of over one million inhabitants, is situated along the Rhine River in the state of North Rhine Westphalia (NRW). It is one of the most flood prone cities in Europe. There have been 12 damaging floods (over 9.5 m) in the past 100 years, five of which occurred in the past 15 years (Umweltbundesamt, 2003). One of many flood prevention measures is minimizing impervious surface.

There are two types of green roof financial incentives employed in Cologne: the NRW subsidy program as described in section 3.1 and stormwater fee discounts as described in section 3.2 and in more detail below. Both incentives are administered by the City Drainage Corporation (Stadtentwässerungsbetriebe Köln, AöR), a public corporation that replaced the City Drainage Department in 2001. In the case of the subsidy, the applications are forwarded to the District of Cologne for processing.

Key Driver

The key driver is a combination of improving transparency and fairness in funding wastewater disposal and a concern for the environment. Using the user-pay principle, fees are based on drained area and stormwater source control is encouraged. In this case, green roofs are just one of several stormwater source controls that are eligible for reduced stormwater fees.

Description of the Policy

Whoever wishes to connect or reconnect to the public sewer system must apply for permission to the City Drainage Corporation. The permit should be attached to any building permit application. Then the owner requires a construction permit for the connection. The City Drainage Corporation then sends out a list of eligible contractors for the job. Wastewater fees are charged after the first use of drinking water. The fee for stormwater disposal is currently 1.10 €/m²/yr ($1.80 Cdn) (Stadtentwässerungsbetriebe Köln, 2004), so the annual stormwater fee for every square metre of impervious surface is a considerable cost to the property owner.

To earn a stormwater fee discount for green roofs as well as other types of source control, the owner must supply the following: a site plan (1:500 or 1:250) which shows stormwater source control measures, a written declaration by the green roof supplier confirming the runoff coefficient of the chosen green roof construction and a completed form entitled, "Stormwater Infiltration Data." The form requires the following information:

- type and area of each surface;
- details about where and how the overflow will be conveyed;
- details about the proposed infiltration systems including roof slope, thickness and runoff coefficient for green roofs;
- whether the applicant has permission from the water authority to infiltrate water on the site;
- whether the proposed drainage will affect the neighbouring properties; and
- whether any connection exists between the infiltration system and the public sewer system.

Performance Goals

Unlike with the NRW subsidy, there is no minimum performance goal like the 0.3 runoff coefficient. Instead performance is measured on a sliding scale so the owner may choose from a wide range of construction types. The stormwater fee discounts (Table 4) for green roofs are based directly on runoff coefficients (Schneider, 2004). Runoff coefficients are determined by the FLL guidelines and confirmed by the green roof supplier.

Table 4: Excerpt from the Wastewater Fee Bylaw of 14.12.2003. Source: Stadt Köln (2003)

Runoff Coefficient	Reduction in fees
C=0.1	90%
C=0.2	80%
C=0.3	70%
C=0.4	60%
C=0.5	50%
C=0.6	40%
C=0.7	30%

If there are changes to impervious surfaces that would change stormwater fees, the Tax Department is notified.

Each green roof is inspected by the City Drainage Corporation to see that it conforms to the requirements as set out in the NRW subsidy and/or the stormwater fee discounts (Schneider, 2004).

Effectiveness

One of the aims of the City Drainage Corporation was to stabilize the wastewater fees. They have succeeded not only in keeping them stable but also in keeping them below 1993 levels (Stadtentwässerungsbetriebe Köln, 2004).

4.3 Berlin: Unique Policies

The Jurisdiction

Potsdamerplatz, Berlin

After the fall of the wall, Berlin became the new federal capital of Germany. Berlin is one of three German city-states, combining the functions of city and state in one – with the Senate having executive function of the government. There are 12 boroughs each with a mayor and six councillors. The population of Berlin is almost 3.4 million.

Berlin is a great learning ground because fresh new approaches to urban design have been and continue to be applied to relatively large and important projects. The unique opportunity to develop the vast central area after reunification of the East and West sectors provided a testing ground for innovative large-scale projects. The oasis of green urban planning is largely a result of the Landscape Program for Berlin 1984/1994 with its four masterplans (for the protection of nature and wildlife, natural resources, landscape and recreation areas) in which values for the relative importance of qualities of nature were defined.

Landscape planners in the administration of Berlin are surprisingly comfortable with new and innovative ideas and are willing to be adventuresome trend-setters with green issues, particularly with the protection of natural resources within the boundaries of the city. Their intuitive acceptance of the less quantifiable, yet scientifically-based green roofs benefits has allowed Berliners to enjoy the many advantages of green roof policy. This trend is one that Canadian cities would do well to adopt.

History

Berlin courtyard
Credit: Manfred Köhler

Berlin has an interesting history of green roof policies. In the 1970's researchers from the Technical University of Berlin began examining the city's green roofs from an ecological perspective while at the same time citizens began pressing for the support of more environmentally friendly cities. Many projects, some of them high profile, were energetically implemented, having been driven by the environmental movement. Between 1983 and 1996, there was the Courtyard Greening Program, aimed at adding green space in the form of green roofs, green facades and backyard community gardens to the most densely sealed areas of the city. Through the program approximately 65,750 m² of extensive green roofs were subsidized (Koehler, 2003c). Residents received a reimbursement for about half, 25 – 60 €/m² ($40 - $96 Cdn), of their expenses for the cost of green roof installation. "By 1983, at least 24 German cities had begun incentive programs which supported urban greening projects such as green roofs, green facades, and courtyard greening projects (Fiebig and Krause, 1983)" (Koehler, 2003c). Later, national and local legislation and policies were implemented that recognized the environmental benefits of green roofs. Direct financial incentives were common during the 1980's and 1990's. Berlin has since suffered from deficits and can no longer afford to offer direct financial incentives; it has turned instead to fees and regulations.

Berlin's stormwater fees are administered by the Berlin Water Corporation, a corporation 50.1% of which is publicly owned. The stormwater fee for 2004 is 1.407 €/m²/yr ($2.25 Cdn) based on impervious surface (BWB, 2004). Green roofs do not earn a discount. However, if the runoff is not connected to the storm drain, the roof area is not counted. The goal is to completely control stormwater at the source, such as by connecting green roofs to swale-trench systems. Green roofs are sometimes integrated into local land-use plans both as source control measures or as nature compensation measures and this is administered by the boroughs. Water protection is administered by the Senate and this may require green roofs as a method for reducing loading on sewer networks and improving water quality. Finally, there is the Berlin Biotope Factor which is examined more closely below.

Biotope Area Factor

Key drivers

New ideas were required to reduce the environmental impact of high density districts in Berlin. Densely developed land is severely limited in its function by:

- a high degree of soil sealing;
- inadequate replenishment of groundwater resulting from rapid runoff of rainfall into the sewage system;
- lack of humidity and excess warming of air; and
- a constant decrease in plant and animal habitat due to inadequate green space.

Description of the policy

The Biotope Area Factor (BAF or BFF for *BiotopFlächenFaktor* in German) was developed in the 1980's in the western sector before reunification. It is a policy tool intended to address the environmental issues listed above. It resembles other urban planning instruments such as floor space ratio. The BAF contributes to standardizing the following environmental goals:

- safeguarding and improving the microclimate and atmospheric hygiene;
- safeguarding and developing soil function and water balance;
- creating and enhancing the quality of the plant and animal habitat especially wild species; and
- improving the residential environment.

The BAF is required in areas with a legally binding landscape plan. There are about 13 such areas in Berlin. Outside these areas, the BAF is voluntary and can be used as a guideline for environmental measures when changes to the existing building structures are proposed. Because of its simplicity and the rising knowledge of environmental issues, architects as well as property owners tend to use the BAF when recommended by experts.

Calculating the BAF

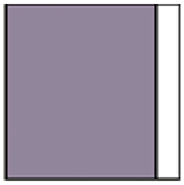
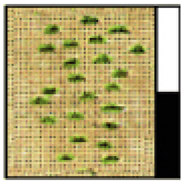
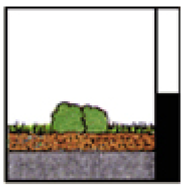
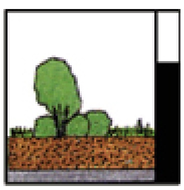
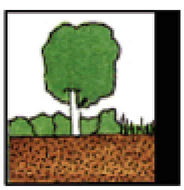
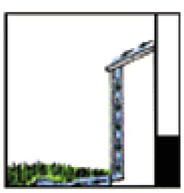
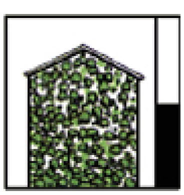
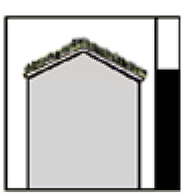
The BAF expresses the ratio between the ecologically effective surface area and the total land area.

$$\text{BAF} = \frac{\text{ecologically-effective surface}}{\text{total land}}$$

For each type of urban form, planners set a particular BAF target value. For example, new residential structures have a BAF target of 0.60 and new commercial structures have a BAF target of 0.30. For renovations, the BAF target may fluctuate depending on the existing degree of coverage. For instance, a residential renovation with a degree of coverage of more than 0.50 has a BAF target of 0.30.

Each type of surface on the proposed plan is measured and assigned a measure of relative importance according to its “ecological value” (see Table 5). For example, sealed surfaces have a 0.0 weighting factor per m² and green roofs have 0.7.

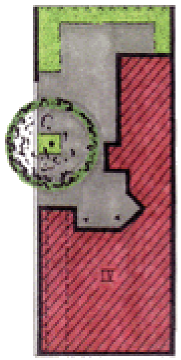
Table 5: Weighting factors. Source: SenStadtUm (2004b)

	Weighting factor / per m² of surface type	Description of surface types
	Sealed surfaces **0.0**	Surface is impermeable to air and water and has no plant growth (e.g. concrete, asphalt, slabs with a solid subbase)
	Partially sealed surfaces **0.3**	Surface is permeable to water and air; as a rule, no plant growth (e.g. clinker brick, mosaic paving, slabs with a sand or gravel subbase)
	Semi-open surfaces **0.5**	Surface is permeable to water and air; infiltration; plant growth (e.g. gravel with grass coverage, wood-block paving, honeycomb brick with grass)
	Surfaces with vegetation, unconnected to soil below **0.5**	Surfaces with vegetation on cellar covers or underground garages with less than 80 cm of soil covering
	Surfaces with vegetation, unconnected to soil below **0.7**	Surfaces with vegetation that have no connection to soil below but with more than 80 cm of soil covering
	Surfaces with vegetation, connected to soil below **1.0**	Vegetation connected to soil below, available for development of flora and fauna
	Rainwater infiltration per m² of roof area **0.2**	Rainwater infiltration for replenishment of groundwater; infiltration over surfaces with existing vegetation
	Vertical greenery up to a maximum of 10 m in height **0.5**	Greenery covering walls and outer walls with no windows; the actual height, up to 10 m, is taken into account
	Greenery on rooftop **0.7**	Extensive and intensive coverage of rooftop with greenery

Calculation example

This example is taken (with editing modifications) from the BAF website of the SenStadtUm (2004b).

<u>BAF ground state:</u>



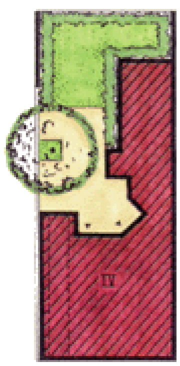
This sample project has a BAF target of 0.30 (residential renovation with existing degree of coverage of over 0.50). The courtyard is mainly covered with asphalt. There is gravel with grass coverage on the periphery and the tree grows in a soil bed that measures 1 m².

Land area	479 m²	
Building area	279 m²	
140 m² asphalt	x 0.0 =	0.0 m²
59 m² gravel with grass coverage	x 0.5 =	30.0 m²
1 m² open soil	x 1.0 =	1.0 m²

BAF 31/479 = **0.06**

BAF target = **0.30**

<u>Planning variant 1:</u>

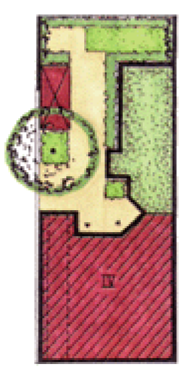


Achieving the targeted BAF will require additional measures that amount to a BAF of 0.24. By reducing the area covered by asphalt and changing the type of surfacing, as well as by significantly expanding the area covered by vegetation, a BAF of 0.30 can be realized.

Land area	479 m²	
Building area	279 m²	
115 m² area covered by vegetation	x 1.0 =	115.0 m²
85 m² mosaic paving	x 0.3 =	25.5 m²

BAF 140.5/479 = **0.30**

<u>Planning variant 2:</u>



Building a covered bicycle stand means that the portion of partially sealed surfaces must be increased. It is therefore necessary to utilize roof and fire wall surfaces in order to achieve the required BAF.

Land area	479 m²	
Building area	279 m²	
21 m² concrete surface	x 0.0 =	0.0 m²
79 m² area covered by vegetation	x 1.0 =	79.0 m²
100 m² mosaic paving	x 0.3 =	30.0 m²
10 m² greenery covering walls	x 0.5 =	5.0 m²
41 m² greenery covering rooftop	x 0.7 =	29.0 m²

BAF 143/479 = **0.30**

BAF and green roofs

There are no specific design requirements or performance goals for green roofs. They must simply conform to industry standards. That said, technical issues are extremely important. In the early days when standards were not well-developed and workers lacked knowledge and experience, there were problems such as erosion of substrates, leaks in the waterproofing and inadequate maintenance leading to the growth of pioneer plant species whose roots sometimes caused damage to the waterproofing (Lenk, 2003).

Training of city staff for the BAF is fairly straightforward because of the BAF's similarity to other planning instruments. However, a shortage of staff has made it difficult to check for compliance. Several years may pass before a green roof is inspected (Lenk, 2003).

Effectiveness

The goals of this policy are numerous and aimed at improving the general quality of the urban landscape. There are so many factors involved that accurately quantifying all the benefits is not possible (Lenk, 2003).

City planners have received positive feedback from architects and property owners who like the BAF because it is easy to use and there are immediate visual improvements as well as energy savings (Lenk, 2003). In addition, it leaves designers and property owners with room for individuality, creativity and flexibility. City planners appreciate that it is formed in the same logic as other planning indices and ratios.

Gille (2003) explained that the BAF works well in older existing neighbourhoods where there is a lack of green space. There is a political decision taken that in cities with limited space, property owners have a responsibility to the greater community to provide green space. In the German constitution, there is clause about private property owners having responsibilities to social good and, in her opinion, this is an important basis for the policy. However, she doesn't recommend it for new developments.

4.4 Linz: Combined Policy Program

The Jurisdiction

The City of Linz, the capital of the county of Upper Austria, is located on the Danube River and has a population of about 190,000. In Austria, each of the nine counties has a Regional Development Planning Act which sets out both mandatory and optional regulations to be included in local development plans. Green roofs were introduced in Linz in 1985 as part of a development plan and are now regularly included in Linz within local development plans.

Key Driver

Plan Excerpt (Linz, 2002)

The key driver for green roof policy in Linz is a lack of green space. The value of green space in the city was first recognized on the Green Space Plan of 1984 for its positive influence on urban climate and ventilation, reduction of dust, ecology, psychological health, recreation, local visual character, etc. (Linz, 2002). Objectives were laid down to improve areas with little or no greenery. Green roofs were seen as effective solutions to greening in areas where land use was not compatible with open space development, such as commercial and industrial zones, and underground structures. The objective of the Green Space Plan for Linz is the retention of an adequate "greening level" and the improvement of insufficiently greened built-up areas. An excerpt from the Green Space Plan is shown here. Red indicates a

Photo by H. Pertlwieser (Linz, 2001)

deficient level of greening, dark orange an adequate level, and light orange a good level. Many photographs accompany the plans to show examples of different levels of greening. The photo shown here shows a fair level of roof greening but a deficient level of greening (such as with trees) in the parking areas.

Description of the Policies

The green roof program for the City of Linz involves two different policies: integrating green roofs into the legally binding development plans, and providing financial support for green roof implementation.

Green roofs were first written into legally binding development plans in 1985. The Linz Green Space Plan 2001 provides standard texts for different kinds of land use which are included in local development plans. The standard text for green roofs is shown below (Linz, 2002). As one can see, not many roofs in the city are exempt of the requirement to be greened.

> *E.g. In the city*
>
> *New and proposed buildings with an area of over 100 m² and a slope of up to 20º, excluding shed roofs, are to be greened. The uppermost layer of the green roof construction shall as growing medium have a thickness of at least 12 cm and the coverage of living plant material shall be at least 80%.*
>
> *E.g. For underground parking*
>
> *The roof surfaces of underground structures are to be greened. The uppermost layer of the green roof construction shall as growing medium have a thickness of at least 50 cm and the coverage of living plant material shall be at least 80%.*
>
> *Green roofs of underground structures must be built flush with adjacent neighbouring properties.*
>
> *When erecting underground structures, at least 30% of the site shall be left free for green areas over native soil.*

In the beginning of the program, roof greening was met with scepticism with the main concern being the higher installation costs of green roofs. To address this concern, the City introduced a green roof subsidy. It was implemented in 1989 and marks the first direct financial incentive for green roofs in Austria. Eligible costs are construction costs from the roof deck up and additional costs associated with upgrading the structural loading capacity of the roof. Up to 30% of eligible costs are reimbursable. Design and contract administration fees are not eligible. The subsidy is offered regardless of whether the roof greening is voluntary or mandatory (i.e. integrated in a development plan), and whether it is an extensive or intensive green roof (Linz, 2000).

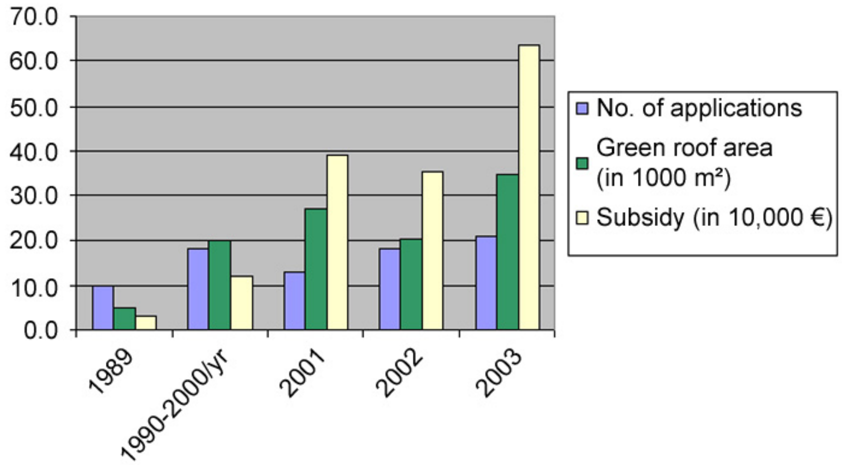
Ensuring Compliance and Maintenance

The public subsidy requires that the roof be maintained over the long-term. This is partially ensured by the provision that 50% of the subsidy is paid after construction and planting and the balance is paid out after the vegetation has established (progress dependent) (Linz, 2000). An inspection is conducted in accordance with the timetable of the committee providing the financial support. The inspector looks at the condition and care of the vegetation, as well as checking the submitted invoices for costs. The main difficulties are lack of personnel for consultation and monitoring. Long-term monitoring of the state of green roofs is currently irregular because of this. Even with the subsidy holdback, owners sometimes do not maintain the roofs properly. The City Planning Department would like to make monitoring an annual program. Aerial photographs have enabled the authorities to monitor the state of some green roofs.

Effectiveness

Since inception of the subsidy program in 1989 until the end of 2001, 237 projects received green roof subsidies. The subsidies totalled 4.77 million € ($7.6 million Cdn) translating into about 268,000 m² of green roofs (Linz, 2002). In the years 2001 and 2002, 740,000 € ($1,184,000 Cdn) were assigned to create an area of 47,000 m² of green roofs. Implementation of the first green roof regulations was difficult because many contractors tried to find ways around them. Now green roofs are no longer a topic of debate and many submitted building plans already contain green roofs.

Figure 1: Development of the green roof subsidy in Linz since 1989. Source: Maurer (2004)



5 Recommendations for Developing Green Roof Policy

This chapter offers some recommendations for developing green roof policies that could be useful in Canada. These recommendations are based on my experience as a landscape architect, derived from literature references and gained through consultation with German green roof experts and policy administrators. I have divided this chapter into three sections. The first one addresses the importance of policy objectives tailored to the needs of each jurisdiction, while the other two sections describe ways to develop and administer green roof policies.

5.1 Policy Objectives

Defining Expected Benefits

Why encourage green roof construction? This is the first question that needs to be asked when considering types of green roof policy, followed by a query about whether there a specific problem to be corrected and how green roofs will address the problem. The design of a green roof affects its performance and therefore its ability to address specific problems. By clearly defining the expected benefits, policy makers will be better positioned to set performance goals and resulting design and construction requirements (Reichmann, 2003).

The objectives are site specific and varied, which may lead to diverse policies across Canada. In Vancouver, for example, the objective might be stormwater retention. In downtown Toronto, it might be microclimate improvement. In Montreal, it might be amenity space. In Calgary, it might be conserving the prairie meadow. In Saskatoon, it might be reducing the need for summer air conditioning.

Targeting Locations and Building Types

In addition to expected benefits, it is important to decide what locations in the jurisdiction and also what types of buildings are targeted. Property owners of different kinds of buildings and developments (e.g. new vs. retrofit, residential vs. commercial) are motivated by different types of incentives. In Germany, combinations of policies such as direct financial incentives in existing built-up areas and development regulations in new development areas have been effective at targeting a broader range of locations and building types.

5.2 Developing and Writing Policy

Selecting Types of Policy

Once the objectives are defined, the question of what type of policy will best achieve them arises. It is important to understand what motivates property owners to build green roofs. I think it is safe to say that they are motivated by direct benefits to the project, costs and by the development approval process. An owner who is provided with good cost-benefit information may choose green roofs without extra incentives simple based on direct private benefits. In the case of costs, subsidies or stormwater fee discounts can be used to offset costs. Finally, there is the option of making green roofs mandatory by integrating them into development regulations.

Setting Minimum Design Requirements and/or Performance Goals

Once the objectives have been defined and a type of policy selected, the question of what requirements the policy imposes needs to be answered. Obviously the policy needs to define how the green roof will differ from a conventional roof. There are two different approaches; one sets specific construction requirements (e.g. minimum growing medium thickness) and the other sets specific performance goals (e.g. maximum runoff coefficient). The advantages of the former are that it can address many goals at once, or goals that are difficult to quantify, and it is relatively easy to measure. This is an important consideration at the stage where the roof needs to be checked for compliance. The advantages of the latter are that it more accurately addresses the goal(s) of the policy and it allows room for innovation. This aspect is important in Canada where there is still much experimenting left to do.

Financial Considerations

How can expected benefits be quantified and translated into cost savings? What is the additional cost for building a green roof? These considerations are especially applicable to financial incentives. Direct financial incentives should take into account the additional cost for building a green roof.

Green roofs cannot be valued accurately on financial aspects alone. Currently, some benefits can be quantified and translated into cost savings while others can be quantified but not easily assigned a monetary value and still others are very difficult to quantify. Stormwater retention and energy savings are among the easier benefits to quantify. Nature compensation can be quantified but not easily given a monetary value. Benefits such as the well-being of building occupants or the beauty of green roofs cannot be quantified. There is a danger that benefits whose monetary value is difficult or impossible to determine are considered valueless. Other ways of calculating benefits need to be considered to improve the accuracy of cost-benefit analyses.

Building Standards

Green roof policies go hand in hand green roof building standards. Construction and maintenance standards are needed to ensure high quality products, establish warrantees, and ensure long-term function.

Detailed standards and guidelines have yet to be produced in Canada. The most detailed ones exist in Germany, thanks to leading green roof proponents like the researchers Hans-Joachim Liesecke, Bernd Krupka and Walter Kolb who have dedicated decades of work into establishing how to design and build green roofs. In Canada, we would do well to learn from this large body of work and experience. At the same time, there are areas where we will need to conduct local research, specifically as green roofs relate to different climates, different legislation, local materials and native plants. The implementation and evaluation of model projects will be useful in developing both policy and standards for future projects (Reichmann, 2003).

The minimum standards need careful consideration. In Germany, high building standards were applied when the industry was young and the companies had an interest in building sturdy green roofs. As the industry grew, thanks to green roof policy, roofing companies adapted to the demand and saturated the market with green roof products.

Suddenly there was intense price competition and the companies were forced to lower their standards in order to remain competitive. Consequently, the minimum standards became the norm.

Even with proper building standards, extreme diligence is needed to ensure that green roofs are built according to specifications. I think it is fair to say that the risk of leakage because of improper construction bothers the minds of even the most dedicated green roof proponents. Remarking about the difficulties in the early days in Berlin, one of my contacts said that people have long memories about leaking roofs and offered this simple advice: build them without holes!

5.3 Policy Administration

Firm Support

Green roof policy should have the firm support of the political decision makers. Any exception to the rule is likely to set a bad example to others who will look for ways out.

In Tokyo, green roofs are required only on flat roofs so owners can easily avoid installing them by having a gently sloped roof. Clearly the wording of the regulations should be clear and not allow for loopholes.

Ensuring Compliance with Performance Goals

Once a policy is in operation, there needs to be a strategy ensuring that the green roof is not only built to last over the long-term, but also that it is built to conform to the minimum design requirements and/or performance goals. One of the challenges is that green roofs are generally more difficult to access and view than conventional green spaces. In Germany some municipalities do not have enough staff to ensure compliance. Sometimes civic employees check roofs on their own time and sometimes the roofs are simply not checked at all. Ways to ensure compliance ought to be considered when developing green roof policy.

Ensuring Proper Long-Term Maintenance

The function or the performance of a green roof needs to continue over time in order for the benefits to be realized. Therefore, the green roof must be properly maintained. Municipalities can ensure maintenance with spot checks (e.g. every two years) or they can require maintenance invoices to be submitted.

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