URBAN SMART GREEN

FROM GREY TO VEGETATED ROOFS

urbanscape®

CONTENTS

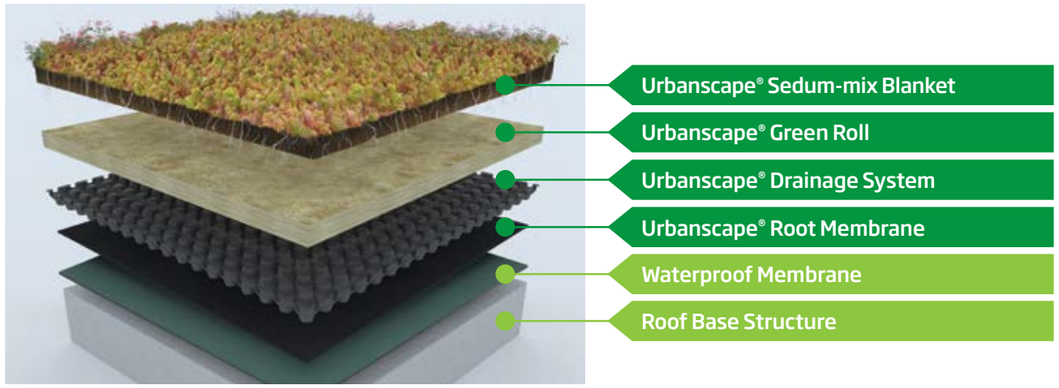
Why Green Roofs?

The design of buildings has evolved over the years, but the function of buildings has remained remarkably constant: protection, comfort, warmth in winter and coolness in summer. In recent years, however, the environmental impact of buildings and green roof solutions are becoming increasingly important.

With the development of a wider view of sustainability, it is critical to remember that from a building lifecycle perspective the environmental impact of any building comes from its energy consumption during the time it is used, the use of renewable energy and the use of sustainable materials.

Green roofs go beyond the meaning of contemporary architecture and give a new value to the role of buildings within urban planning. They are designed not only to bring back the natural element in the urban environment but also to provide solutions for important issues such as urban heat island effect and stormwater management.

Urbanscape® Green Roof System - innovative, lightweight and easy to install system with high water retention capacity.



GREEN ROOFS

A POTENTIAL NEW HABITAT FOR PLANTS AND ANIMALS IN URBAN AREAS

In the summer of 2015, biodiversity was evaluated on sedum roofs in the Netherlands. In the process, the following species were observed: 3 types of diurnal butterflies, 29 types of nocturnal butterflies (moths), at least 4 types of wild bees, at least 7 types of hoverflies, 4 other insect types and 4 sorts of birds. The substrate layer was also investigated, and showed that this layer is also suitable for the pupal stage of many butterfly species. But will every roof scheme prove as successful? Can every green roof become biodiverse? Are there any differences between intensive and extensive green roofs? Let's find out.

BUT FIRST – WHAT IS BIODIVERSITY AND WHY IS IT IMPORTANT?

The term biodiversity refers to the great variety of life on Earth at all levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it. Biodiversity includes not only species we consider rare, threatened, or endangered, but every living thing. Biodiversity is important everywhere; the species and habitats in your area, as well as those in distant lands all play a role in maintaining healthy ecosystems.

WHAT IS THE CONNECTION BETWEEN GREEN ROOFS AND BIODIVERSITY?

Wherever buildings are constructed, microhabitats are usually disrupted. Green roofs, like other constructed ecosystems (e.g., sewage treatment wetlands, bio swales for storm-water management, or living walls), **mimic natural ecosystems to a certain extent** in order to provide ecosystem services, and are potential new habitats for plants and animals in urban areas. For example, on top of one of the Ford Motor Company's assembly plants (Dearborn, Michigan) one of the world's largest green roofs, with a mix of 13 Sedum species, was planted in media less than 7.6 cm deep. Within two years of initial plant establishment, 29 insect species, 7 spider species, and 2 bird species were identified on the 42,900 m^2 greened roof (Coffman and Davis 2005).

WHAT AFFECTS BIODIVERSITY ON GREEN ROOFS?

A few key factors influence the biodiversity of green roofs:

1. Location of the roof: a greater variety and quantity of species can be expected on the roof of a building situated in a natural environment rich in a variety of species than on the roof of a building located in the middle of an industrial zone where the variety of species was comparatively limited.
2. Roof configuration (edges, height and similar).
3. Increased variety of plants (heterogeneity), types of growing substrates.
4. Small constructions on the roof that provide nesting opportunities (e.g. wooden nesting blocks, stones). This way, an environment that mimics a natural habitat is built to support a variety of birds, plants, invertebrates and other animals.

CAN NATIVE PLANTS BE PLANTED ON THE GREEN ROOF?

YES, sometimes. But strong evidence shows that the majority of such projects fail, especially where we find a lack of maintenance. Such an approach clearly demands more specialist knowledge in the design phase and deeper growing mediums, while the maintenance component requires more labour, resources and expertise in the longer term. The designer has to be well aware of the implications of this kind of approach – and ensure clients are aware as well. Everyone involved with such a project should be clear that this is pioneering, not proven work (McIntyre, Snodgrass, 2010).

IF THE CLIENT REQUIRES A BIODIVERSE ROOF WITH NATIVE OR OTHER VERY DIVERSE PLANTS, WHAT ADVICE CAN SOMEONE GIVE HIM?

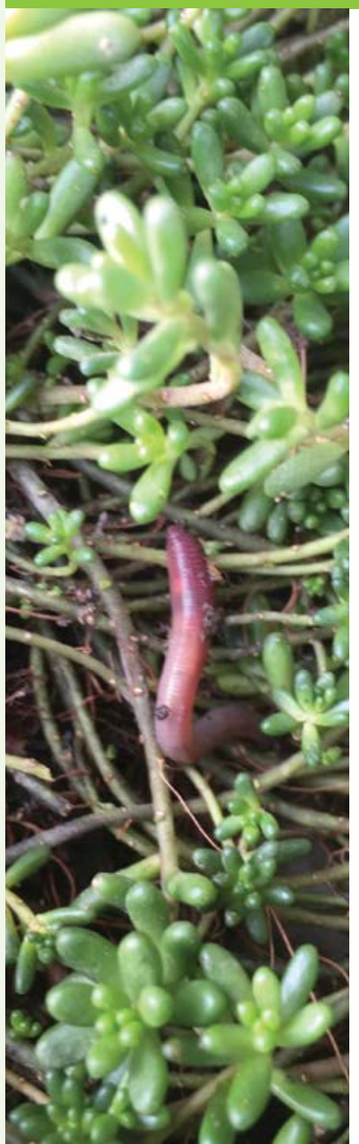
Selecting and obtaining the right plants can be difficult and time consuming, and the strict site specifics of such an approach often means that there are few lessons that can be taken from successful examples in other regions. Often, even if such plants are properly identified and available in the marketplace, they struggle in the harsh conditions on the roof. Even in a garden on a grade, using native plants to improve ecological functioning and provide a habitat is not simply a matter of choosing a few natives and adding them to the plant list. Restoration ecology requires scientific expertise and knowledge of horticulture, biology, soil science, climate, hydrology and how the various characteristics of a site interact. On a roof, there is nothing to restore (McIntyre, Snodgrass, 2010).

HOW, WHEN WE TALK ABOUT IT, CAN BIODIVERSITY ACTUALLY BE EVALUATED, EVEN PROVEN?

Flower-visiting insects are one key indicator of the quality of the nature in a given area: the presence or absence of these animals is an important indicator of the state of the environment. Butterflies and bees in particular, as well as hoverflies and other flower-visiting insects, play an important role in serving the ecosystem, namely in pollinating both wild and cultivated plants. But evaluating the number of species that visit a green roof is only the first stage. Then one should also understand the relationship between the roof and that species, to determine whether the roof can be a functional environment for individual members of the species.

WHAT ARE THE PLANTS GROWN ON URBANSCAPE® GREEN ROOFS?

On Urbanscape® green roofs, several sedum species are present, mixed in random patterns. In the first two years, evergreen sedums dominate, while in the later stage big-leaf sedums grow and mature over time. The composition of the vegetation is dynamic and varies. Having several sedum species in the blanket enables vegetation coverage through the seasons; and consequently, the overall visual impression changes with the season. Flowering of Urbanscape® Green Roofs occurs mainly during the late spring and summer.



IS A BIODIVERSE ROOF SUITABLE FOR EVERY ROOF?

NO.

for the following main reasons:

1. A biodiverse roof with a wide variety of plant species requires a deeper growing medium, which contributes to the weight load; often, building statics limit or prohibit such loads.
2. A biodiverse roof is more expensive to plan and install both in the initial phase and over its lifetime, since it requires special maintenance and constant, intensive care and special knowledge.
3. A biodiverse roof often fails due to the very specific vegetation demands of the environment.

IN THE END, CAN WE CLAIM THAT A GREEN ROOF IS A NATURAL HABITAT?

NO.

Even when it is a very carefully designed intensive roof, it still only mimics a natural habitat to a certain extent in order to provide some ecosystem-specific features and services.

HOW MUCH DOES A GREEN ROOF WEIGH?

GREEN ROOFS MAY COME IN AN ENDLESS VARIETY OF SHAPES AND SIZES FROM HIGH-RISE PUBLIC PARKS AND LUSH ROOFTOP GARDENS TO TRANQUIL URBAN SPACES, BUT THERE IS ONE CRITICAL FACTOR THAT HAS A MAJOR IMPACT ON THEM ALL — WEIGHT.

Green roof weight can range from hundreds of tons for an 'intensive' green roof such as a small urban park or garden to just a couple of hundred kilos for a lightweight 'extensive' green roof system like Urbanscape® featuring a lush mix of sedum vegetation.

WHAT CONTRIBUTES TO GREEN ROOF WEIGHT?

The two key elements that contribute to weight are **the density of the different layers** that make up the green roof and **how heavy it becomes as a result of rain absorption.**

A **traditional 'intensive' green roof system** for plants and grass — featuring at least six layers including soil, filter fleece, drainage layer and vegetation — is up to 12 cm thick and weighs around 100 kg/m² dry and 150 kg/m² fully soaked.

Compare that to Urbanscape®. The green roof solution uses a unique lightweight growing media rather than soil and as a result is less than 8cm thick and six times lighter than traditional systems weighing only 20 kg/m² dry or 65 kg/m² saturated.

SO, WHAT ARE THE IMPLICATIONS OF THESE WEIGHTY ISSUES?

AS SURFACE AREA INCREASES, THE WEIGHT OF GREEN ROOFS OBVIOUSLY INCREASES PROPORTIONALLY. SO, **A 50 M² TRADITIONAL GREEN ROOF WEIGHS AROUND 5 TONS WHILE A SIMILAR-SIZED URBANSCAPE® ROOF WEIGHS JUST 1 TON.** SCALE THIS UP AND A 1,000 M² TRADITIONAL GREEN ROOF SPACE REQUIRES 100 TONS OF MATERIAL AND THE URBANSCAPE® VERSION ONLY 20 TONS.

WHAT IS THE IMPACT OF GREEN ROOF WEIGHT ON BUILDING STRUCTURE?

A traditional green roof can exert a load of up to 250kg per m² and that inevitably means a strong building is required to support the weight.

In older buildings or new-build this may require costly structural reinforcement which in some cases may prove prohibitively expensive. The solution is simple. If the weight of the green roof is reduced the need for structural reinforcement is also reduced.

As mentioned, **Sedum vegetated green roof designed by Urbanscape® is six times lighter than traditional green roof systems.** This lightness means most buildings have a comfortable load-bearing capacity that is sufficient and architects can even plan green roofs where it had not been possible before such as on lightweight metal constructions.

HOW DOES WEIGHT IMPACT INSTALLATION COSTS?

Traditional green roofs usually involve detailed planning, tons of soil, lots of installation time and horticultural expertise… in other words, **plenty of money**.

With **Urbanscape®** there are no complicated drainage systems or expensive roof preparations to install. Each element from the mineral wool growing layer to the root barrier membrane is light and easy to handle and no specialist knowledge is required to install it. This means **installation is effortless and efficient**. When Urbanscape® was installed on a 500m² residential complex in Germany, for example, it took just a day's work of standard installation team to complete the entire system. That's half the time it would have taken to install a traditional green roof.

HOW DOES WEIGHT IMPACT ON INITIAL MAINTENANCE?

A **traditional green roof** with soil substrates are usually designed with plugs, cuttings or seeds which consequently require **much care and attention in first years** to reach good green coverage and diverse vegetation. This increases dramatically the cost in comparison to pre-vegetated green roofs. Naturally if building owners introduce plants, grass or shrubs, they also need to find money to employ someone to nurture their investment and ensure it is kept in peak condition.

Urbanscape®'s vegetation layer is composed of a sedum mix grown by top sedum grower. This lightweight vegetative mix provides an **instant oasis of green diversity from the minute it is installed.**

4 KEY GREEN ROOF PERFORMANCE INDICATORS YOU SHOULD (AND CAN) KNOW MORE ABOUT

GREEN ROOFS HAVE GAINED GREAT ATTENTION OF URBAN PLANNERS AND ARCHITECTS RECENTLY DUE TO SOME OBVIOUS BENEFITS SUCH AS AESTHETIC VALUE, INCREASED BIODIVERSITY AND IMPROVED MICROCLIMATE CONDITIONS IN CITIES BY REDUCING THE HEAT ISLAND EFFECT.

IT IS CLEAR, HOWEWER, THAT WE NEED TO MOVE GREEN ROOF DESIGN BASED MOSTLY ON AESTHETIC PERFORMANCE IN TO DESIGNING GREEN ROOFS TO MATCH REQUIRED PERFORMANCES, SO URBAN PLANNERS AND ARCHITECTS CAN USE THEM TO THEIR FULL POTENTIAL.

KEY PERFORMANCE INDICATORS OF GREEN ROOFS

There are four key performance indicators of green roofs that are important tools for urban planners, municipalities and architects to manage not only building project, but also their energy and water policies.

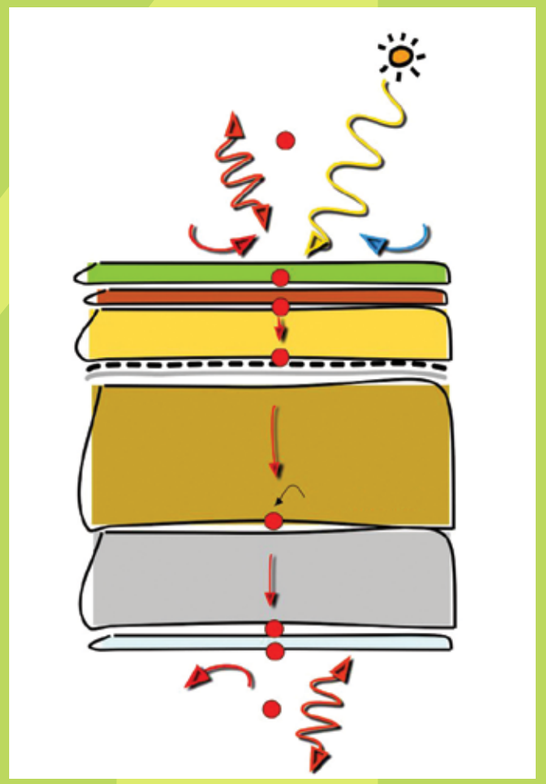
1. **Energy performance of green roofs in summer** (cooling effect)
2. **Energy performance of green roofs in winter** (thermal insulation)
3. **Rainwater or stormwater management performance**
4. **Performance in reducing the heat island effect**

The performance of these key indicators can be objectively measured.

However, one need to keep in mind **there are a lot of factors that can influence the performance of sedum based vegetative roofs.**

- Type of Green Roof (thickness and type of growing media, type of drainage, type of plants).
- Type of building construction (metal, wooden, concrete) and design of the roof (what kind of insulation is used, what kind of water proofing ...).
- Additional aspects such as climate conditions, additional irrigation or not, as well as condition in the building itself (average temperatures in the building).

So considering all above, simply saying 25% or 75% saving of energy and 90% rainwater retention (which is to often the case) can be misleading and can often causes disappointment when optimistic figures are not reached.



Elements effecting real performance of Green Roofs

URBANSCAPE® INTRODUCES GREEN ROOF PERFORMANCE EVALUATION TOOL (PET)

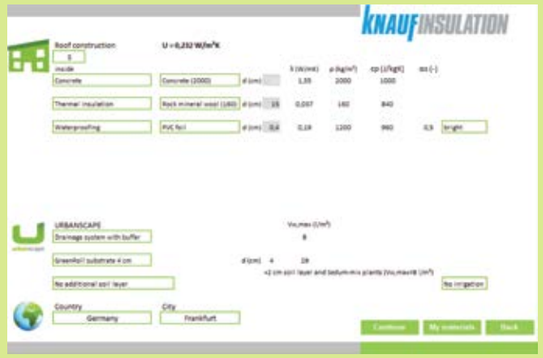
Urbanscape® Performance Evaluation Tool is based on the results of a 2-year in-situ performance study of different types of Urbanscape® Green Roof Systems in different climate conditions. The study "Thermal and hydrological response of green roofs in different climatic conditions" was made by Urbanscape® Green Solutions Team of experts in collaboration with Faculty of Mechanical Engineering, University of Ljubljana. Based on the results of this extensive study we are now able to define economic and environmental advantages of a green roof.

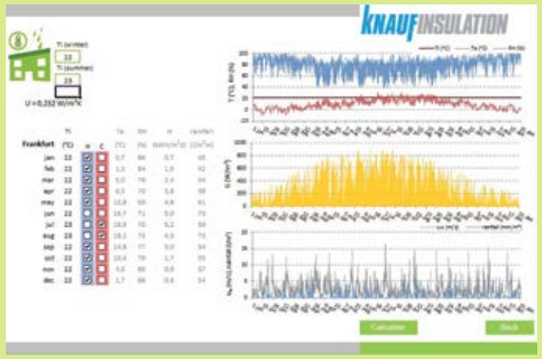
The results have been used to prepare special software package ***"Urbanscape® Performance Evaluation Tool"*** or simply ***PET***". The PET helps current and potential users/ owners, urban planners, architects and designers to get to know the real performance of a green roof in detailed numeric and graphic data reports.

URBANSCAPE® PERFORMANCE EVALUATION TOOL USAGE AND REPORTS

The Urbanscape® PET software package is simple to use. It requires a 3-step user input:

- Definition of building construction, roof type, outer surface optical properties of the roof.
- Definition of Green Roof layer components composition and thickness; and irrigation scenario.
- Selection of site meteorological parameters and definition of mean in-house temperatures of specific building during different periods (winter – during the heating season and summer – during the cooling season).





The results are then presented in a simple report and cover the 4 key performance indicators:

- Cooling effect and energy saving in summer due to less air-conditioning needed.
- Thermal insulation effect and energy saving in winter due to lower energy transfer through the roof.
- Rainwater management control data including water retention in the green roof and yearly / monthly run-off data (all based on real climate conditions).
- Temperatures on top of the Green Roofs vs regular roofs (positive effect on UHI).

The results are presented in the form of graphs with hourly, monthly, seasonal and yearly values of calculated parameters comparing performance of building with installed Green Roof vs. same building w.o. installed green roof.

With Urbanscape® Green Roof Performance Evaluation Tool we are now a step closer to really understand the benefits green roofs offer, energy savings they provide and overall environmental impact of buildings in highly populated urban areas, which are facing several ecological and environmental issues.

If you are interested in receiving your own Performance evaluation report for a selected town / country or for a project-specific roof, contact us via **urbanscape@knaufinsulation.com**.

Green Roof Benefit

Reduction of Urban Heat Island Effect

Green roofs are one of the most effective ways to reduce the ambient air temperature in urban areas. During summer the temperatures in cities are approximately 5-7°C higher than in the countryside due to buildings and roads heat absorption and **the temperature on the traditional roof can be up to 40°C higher compared to the green roof**. According to research carried out by the Tyndall Centre for Climate Change there is a need of 10% more greenery in towns to mitigate the UHI Effect.

THREE KEY
ELEMENTS AFFECTING
THE REAL ENERGY PERFORMANCE OF GREEN ROOFS

Green roofs can be good energy optimization tools for buildings. But in order to understand real performance, we need to understand what affects the real energy saving performance off a typical Green Roof building.

Over the past years Urbanscape® Green Solutions Team has evaluated more than 100 different green roofs in different climate areas, with different thermal insulation schemes on the roofs and with different types of general construction.

The results the team came up with are really eye-opening…

1 TYPE OF BUILDING CONSTRUCTION

It is generally known that concrete roofs work much better than metal roofs when we want to prevent sun energy from entering the building in summer, and similarly, by preventing heat and heating energy from escaping the building in winter.

We also know that once the concrete building has heated up in summer, it stores the energy and acts as an oven on hot summer nights.
To understand the influence of roof construction type on Green Roof energy performance we evaluated two identical green roofs on similarly insulated buildings in Barcelona. The only difference between the two was construction type: the first was a concrete roof, and the second a steel roof.

Results revealed that during a summer day, the **steel roof performed far worse**, as there is a big transfer of heat into the building during peak noon/afternoon hours, so air-conditioning systems have to be used extensively. In summer, a concrete roof with the same insulation performed as much as two times better than a similarly insulated steel roof.

Despite winter conditions that are not particularly severe, the same Green Roof Energy performance ratio between concrete and metal structures was also recorded in the winter.

By putting a Green Roof on top, this difference can be minimized. Green Roof Energy performance in summer on the metal building was twice as good (8 W/m² solar energy transfer reduction) as the performance on the concrete building (4 W/m² solar energy transfer reduction).

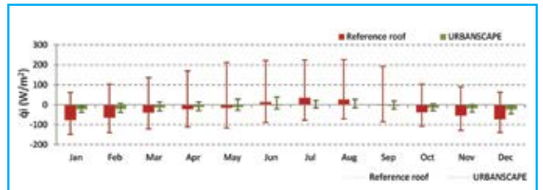


CHART 1 Energy transfer through the metal roof

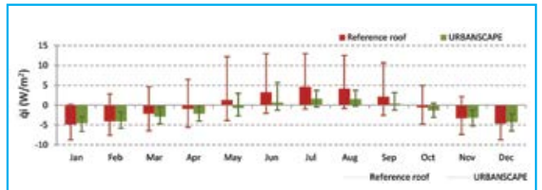


CHART 2 Energy transfer through the concrete roof

So a factually proven statement would be: "Green roofs in Barcelona have a bigger effect on energy performance on steel roofs than on concrete roofs.

2 THERMAL INSULATION

In order to gain some insight into how insulation thickness affects Green Roof energy performance we compared similar roof constructions, where only **different insulation schemes were implemented.**

We were looking at **concrete roofs in Munich with different insulation thickness of 0–20 cm**. Again, the results are simply all over the place. If a concrete roof has no insulation the building will be hugely inefficient.

If we add a green roof on the top of an uninsulated building, energy transfer in or out of the building can be reduced by as much as 140 kWh/m² per year.

By adding 10 cm of insulation, this effect decreases dramatically to just 3.7 kWh/m² per year; adding 20 cm of insulation brings the figure down to just 1.2 kWh/m² per year.

The data clearly shows that insulation matters. When a roof is not insulated, a green roof solution has a tremendously positive effect on the energy performance of the building. As soon as we have insulation, the performance drops significantly. Increasing the insulation up to 20 cm would actually almost "kill" the energy performance of Green Roofs in Munich.

It is also important to know that a far greater effect is seen in Munich during the heating season than in the cooling season.

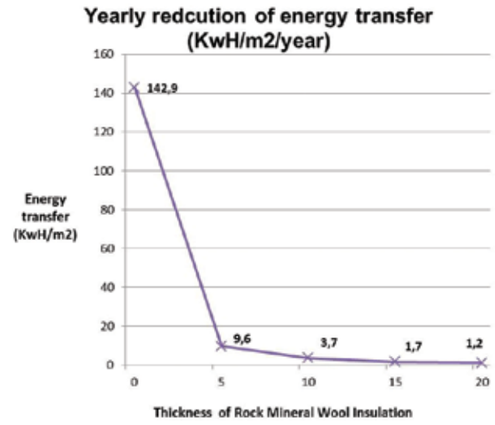


CHART 3 Energy transfer reduction in dependence to insulation thickness.

3 CLIMATIC CONDITIONS

Local climate has a big effect on Green Roof energy performance. For this reason we have compared the same type of flat roof construction, including with a green roof on top, on **two different locations, in Munich and in Barcelona.**

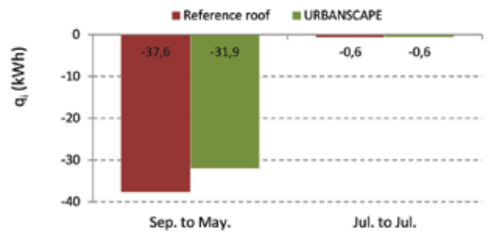


CHART 4 Concrete-based structure with 10 cm RMW insulation, Munich

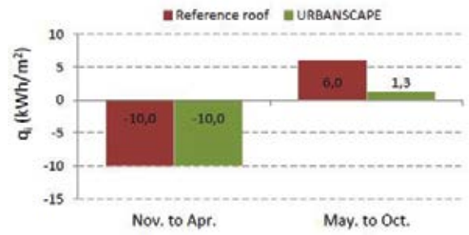


CHART 5 Concrete-based structure with 10 cm RMW insulation, Barcelona

Despite the fact that on a yearly basis there was not a big difference in Green Roof, energy performance was 25% better in Barcelona than in Munich. The biggest difference in performance was related to the seasonal effect**. In Barcelona, which has a Mediterranean climate, the biggest savings were seen during the summer (cooling period), whereas in Munich, which has a Central European climate close to the Alps, savings were seen in both summer as well as in winter.**

DO NOT FORGET

Taking all of the above into consideration, it is important to understand all the facts, influencing energy saving performance before going to municipalities to discuss what Green Roofs might do for the city's overall energy efficiency.
Simply pointing to a 25% reduction in winter and a 75% reduction in summer is just misleading.

Green Roof Benefit

Rainwater retention

A major advantage of green roofs is the reduction of storm water run-off, which leads to **a decrease of the burden on sewer systems by 70-95% in summer.** Green roofs have influence on cost reduction due to low or no need for rain-catching cisterns and similar equipment which is usually used for storm water management. Rainwater retention capability helps to limit accidents caused by heavy rainfalls.

Rainwater purification

Through natural bio-filtration, green roofs prevent contaminants and toxins from reaching streams and waterways. According to Kohler & Schmidt research (1990) **95% of the lead, copper and cadmium sulphide and 19% of the zinc coming from the rainwater remains in the substrate,** which helps to improve local water quality.

CO_2 reduction

Green roofs help to reduce the amount of CO_2 in the air, which is considered one of the most important causes of global warming. **1m² of a green roof can absorb 5 kg of CO_2 yearly.** Additionally, due to reduced energy consumption there is a further impact on carbon dioxide reduction by 3.2kg yearly.* As a perspective, 1m² of green roof can absorb the same quantity of CO_2 as a regular car would emit during a 80km drive.

Short version! Long version was presentedat Cities Alive 2016 Conference, Washington DC.

PROMOTE GREEN ROOF STORMWATER PERFORMANCE WITH MINERAL WOOL LAYER

INTRODUCTION

The effects of adding the binder-free mineral wool layer into the green roof systems for their performance enhancement are studied on lab scale as well as in real case scenarios. Binder-free mineral wool layer is inorganic and stable media, which can significantly improve the performance of the green roofs in terms of stormwater management, increased energy savings and physical appearance of the green roofs.

MINERAL WOOL IN GREEN ROOFS

Wong and Jim (2014, 2015) investigated the storm water mitigation by green roofs in humid tropical climate, focusing mainly on effect of different substrate depths and addition of rock wool. Authors explain that rock wool serves as water reservoir as well as supplementary substrate layer. Replacing all or part of the soil substrate with lightweight rock wool can reduce the overall load and lead to more extensive retrofitting of existing roofs; provide the additional evaporative cooling (due to high water holding capacity) and to enhance acoustic insulation when dry. Incorporating rock wool can help maximize retention capacity and peak mitigation if the rainfall events are preceded by a prolonged dry period.

Teemusk and Mander (2007), and Mentens et al. (2003) incorporated rock wool layer in their green roof designs, although their research findings do not explore specifically the effect of rock wool layer as such on the storm water performance of studied green roof. First study shows how the light weight aggregates based green roof tackles with storm water retention and quality of runoff water. Authors indicate that the roof retained up to 85% of water, depending on the initial moisture and type of rainfall event.

Regarding energy efficiency effect of green roofs with mineral wool layer, Arkar et al. (2015) reveal findings on the winter time heat losses: these are smaller in case of green roof then in case of reference roof – within 24 hours during the night-time (when heat demand is the highest), and on the monthly bases, up to 14 %. This difference is significantly higher during summer period.

BINDER – FREE MINERAL WOOL LAYER

Green roofs do contain growing media with different proportion of organic fractions inside. Part of green roofs is already used to be combined with mineral wool media with most likely effect of improving the moisture content in various green roof systems.

For last few years, one can observe the usage of innovative, needled mineral wool growing media which contains no binder. This mineral wool layer differs from classic mineral wool due to the improved production process, which enables needling of mineral fibres into porous lightweight layer that represents excellent media for plants rooting and growing.

Already visual observation shows the difference:

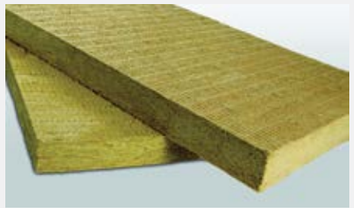


Photo 1 *Classic mineral wool hard boards, with binder*

Photo 2 *Binder-free mineral wool*

Needled mineral wool is made of abundant rock - mainly volcanic - materials without any additives or binders (general composition of rock mineral wool is described in Table 1 and samples of fibres shown in Photo 3 and 4). This allows the open structure of the material, which can easily absorb the large amount of water. So 4 cm (1, 6") thick layer of such material can easily absorb up to 29 litres of water per sqm (0,7 gallons/sqft; 1,05"). The density of material used is from 100 – 130 kg/m³ (6,25 – 8,11 lb/ft3).

To compare this with the soil, mineral wool is approx. 10 times lighter which is important aspect when thinking about installing the green roof. The majority of space in a cubic meter of the mineral wool is air, opposite to soil where majority is solid matter with air (and water) inside. When saturated and compressed, the air content in this layer is approx. 10%.

Mineral fibres remain stable in terms of chemical composition as well as with clean breaks, as shown on Photo 4, with no significant signs of aging (also confirmed by simulation aging results in environmental chamber). Small particles attached to the fibres are soil remaining, as confirmed by EDS analysis. When installed on the green roof with the pre-vegetated Sedum blanket on the top, quick rooting is evident (Photos 5 and 6).

HOW DOES THE MINERAL WOOL PERFORM WHEN APPLIED ON THE GREEN ROOF?

On the test plot in Sterling VA (close to Washington DC, see Photo 7), the effect of adding the mineral wool layer in green roof system was studied, in comparison with green roof without mineral wool layer. The moisture content was measured on three depths, with sensors being installed on 3,5" (blue line), 2,5" (red line) and 1,5" (green line in the graph) depth respectively. The data shown is for period of one month, more exactly April 2015. First graph shows moisture content in green roof with 1" mineral wool layer and 3" of soil, and second one with 4" soil layer. In both set-ups, the vegetation used was uniform (Sedum ssp.), the soil composition and drainage layer used were the same.

When comparing the green roof system with and without the mineral layer (to achieve the same height of the system, in case of mineral wool added, the layer of soil is 25% thinner in comparison to "soil only" green roof), the following is observed:

- The total amount of moisture in the system is higher in the case of mineral wool added through the year;
- The highest difference in moisture content can be seen in 3,5" depth as expected (due to the water buffer in the mineral wool layer).
  The drainage board bellow mineral wool is always needed, as it will allow drain excess water to avoid plant suffocating and allowing appropriate water-air ratio through the whole system;
- On depth of 1,5" and 2,5", the difference is less visible, but constant. The moisture in 1,5" depth in "soil only" case is on the average level around 0,06 m^3/m^3 constantly with exception of three peaks when 10% moisture is reached. In case of mineral wool added, the moisture content is a) more stable and b) very close to 10%. This is important for the water supply of the plants especially in warm periods of the year. This is evident also in colder period, e.g. in November 2015, where the average VWC is higher and more stable in case of mineral wool (0,418 m^3/m^3 in 1,5" depth and in depth of 3,5" ranging from 0,079 m^3/m^3 being a minimum and up to 0,127 m^3/m^3 being a maximum, containing 10% as an average). The soil based system resulted with 0,153 m^3/m^3as average VWC in 1,5" depth, and in depth of 3,5" reaching 0,087 m^3/m^3VWC;
- When adding mineral wool layer in green roof system, the water retention of the system significantly improves. Due to the larger water absorption capacity the runoff volumes are reduced and delayed. Reduction of sewer overflow events are expected and energy savings are higher due to the increased water kept inside relatively thin green roof system where bottom water can still be used for evapotranspiration, more active photosynthesis process of the vegetation cover and therefore more successful UHI effect mitigation.

From analyzing rainwater outflow from green roofs of different set-ups (KI internal report, 2013), it can be concluded that, in a condition of a constant rainfall, a dry mineral wool layer of thickness 0,8" (module 2 and 4) can retain 15 liters of water per m^2 of roof surface area (0,35 gallons/square feet), a dry mineral wool layer of thickness 1,6" (module 3) can retain 23,7 liters of water per m^2 (0,57 gallons/square feet) of roof surface area, while the darkest blue line (module 1) shows the reference's (non-vegetated) roof outflow. Once the green roof system is saturated (with more frequent / constant precipitation), the runoff retention and delay in case of stormwater events is of course changed.

COMPONENT MINERAL	CONCENTRATION RANGE (%)
SiO_2	37 - 45
Al_2O_3	6 -15
MgO + CaO	16 -41
Na2O + K_2O	0,5 - 5
B_2O_3	<1
Fe_2O_3	4 - 10
TiO2	0,5 - 3,5
P_2O_5	<1

Table 1 General composition of rock mineral wool fibres in % (variations as shown can occur due to different batches and varied composition of the rocks).

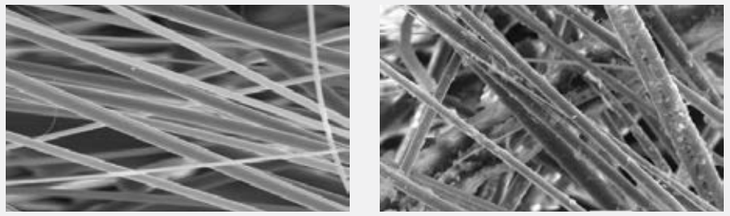
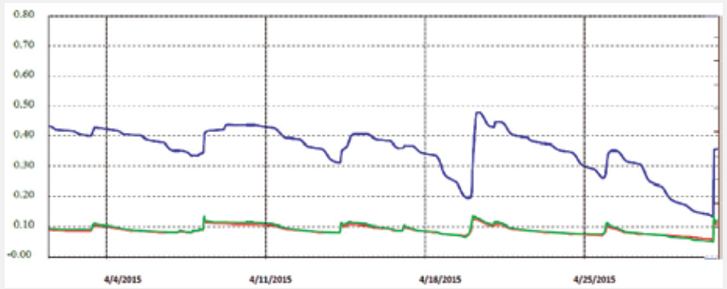


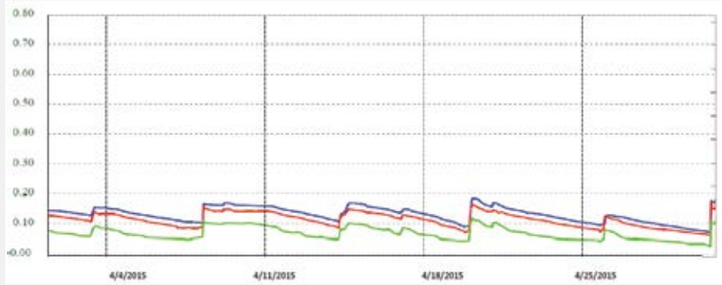
Photo 3 and 4 Left - Rock mineral wool without binder – not used material (SEM analysis, zoom 1000x). Right - Rock mineral wool after three years of installation (SEM analysis, zoom 800x). Source: Institute Jožef Štefan, 2014.

Photo 5 Mini rooting after two weeks

Photo 6 Complete rooting after eight weeks.

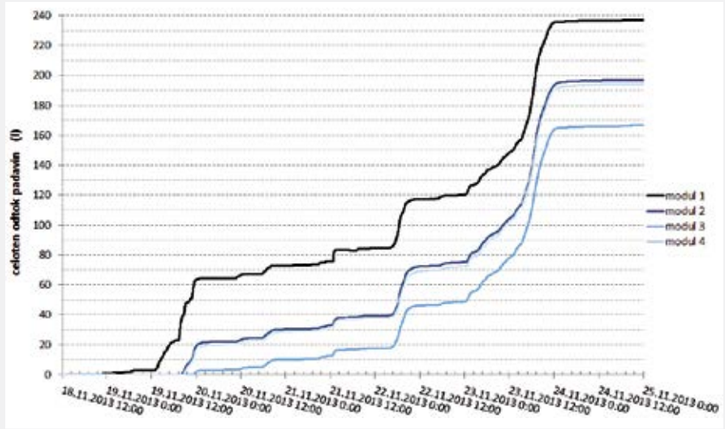


Graph 1 Green roof Volumetric Water Content (VWC, m^3/m^3) with mineral 1" wool layer beneath the 3" soil and Sedum vegetation. Drainage layer beneath. Source: KI internal report, 2015, daily data collected with Datatrac.



Graph 2 Green roof Volumetric Water Content (VWC, m^3/m^3) with the 4" soil and Sedum vegetation. Drainage layer beneath. Source: KI internal report, 2015, daily data collected with Datatrac.

Photo 7 Test plot, Sterling VA, USA. 2014.



Graph 3 Stormwater retention and delay on green roofs with mineral wool layer (module 2,3 and 4) in comparison with reference, non-vegetated roof (module 1).

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Advancements in Efficient Stormwater Management in Vegetated Roofing

Vegetated roofing has long been recognized as an effective stormwater management tool in urban centres to help store and attenuate runoff from impervious rooftops. New technological advancements are helping further increase stormwater retention capacity on rooftops while keeping weight low.

One such significant advancement is the use of rock mineral wool (RMW) – which offers both advantages – in place of a greater depth of traditional growing medium.

There are several varieties of mineral wool on the market, produced for different applications. When it comes to stormwater retention and vegetated roof survivability, not all mineral wools are created equal. As the lifespan of vegetated roofs may be several decades, it is imperative to understand the differences in varieties of RMW, as well as their effectiveness and durability as stormwater management tools.

History

Mineral wool is a general term for a light, artificial wool made of an inorganic substance such as glass, stone, or slag. It was originally invented in the mid-19th century for thermal and acoustic insulation in the construction industry.

Almost 50 years ago, a modified form of RMW in the form of slabs, blocks, and bonded fibres started being used as a substrate in hydroponics in Denmark.[1] Today, it is present in virtually all advanced horticultural markets, and is used for growing hydroponic fruits, vegetables, herbs, and flowers.

RMW for vegetated roofing applications is manufactured by a fiberization process induced by heating a mixture of various rock components (usually diabase, dolomite, granite, basalt, etc.), which are melted together at high temperatures.[2] The melt is spun into thin fibres on fast-rotating machines and is later bound for dimensional stability. Generally, there are two major differences between methods of making the loose, melted rock fibres dimensionally stable and transforming them into slabs, blocks, or wool. They can be bound using a chemical-free needling process to physically interconnect loose fibres, or those loose mineral wool fibres can be glued with binders.

Examples of the latter option include:

- sodium silicates;
- polyesters;
- melamine urea formaldehyde;
- polyamides;
- resin-based phenolic; or
- furane-based resins.[3]

Developments

Advancements have been made in the manufacture of mineral wool over the decades, offering environmental alternatives and products with superior performance.
One development has been the use of **formaldehyde-free** binders, which rely on renewable resources. This new generation of mineral wool is an environmentally responsible alternative to phenol-based products. It uses renewable resources for binding agents and has enhanced water absorption characteristics.
The most notable development is the production of the needled rock mineral wool, manufactured without additives or binders. It is important to understand how this engineered product supports long-term stability and stormwater retention performance in outdoor applications such as vegetated roofing.

Categories of rock mineral wool

Various types of RMW are currently available, each with unique advantages, drawbacks, and properties.

Traditional binders

The most common mineral wool on the market is sprayed or bound with phenolic resin or diluted phenol-formaldehyde (PF) for dimensional stability. These binders also help make the product water-repellent. This type of mineral wool is typically used as insulation in the construction industry.

When traditional mineral wool is modified with a hydrophilic (or wetting) agent, it can be used as a growing media for hydroponic cultivation in a strictly controlled environment. If this type of mineral wool is used as an alternative to other growing media, it requires uniform conditions such as a greenhouse where usage cycles are relatively short (*i.e.* from one growing season to five, in the case of ornamental plants). If it is exposed to varying, uncontrolled climatic conditions (*e.g.* dry/wet periods, freeze/thaw cycles, or high/low temperatures) for longer periods, its water-holding characteristics will change significantly, resulting in decreased hydrophilic ability. In other words, cycles of drought or precipitation will negatively influence the material's long-term performance and water absorption capacity. This phenomenon likely occurs due to the hydrophilic agent rinsing out, which causes the initial hydrophobic character to prevail.

Therefore, traditional mineral wool is not ideal for outdoor applications such as vegetated roofing. Its hydrophobic propensity renders it an inconsistent and unreliable stormwater management product over time, unable to effectively sustain rooftop plants under significant stress in hot and dry seasons.

Formaldehyde-free binders

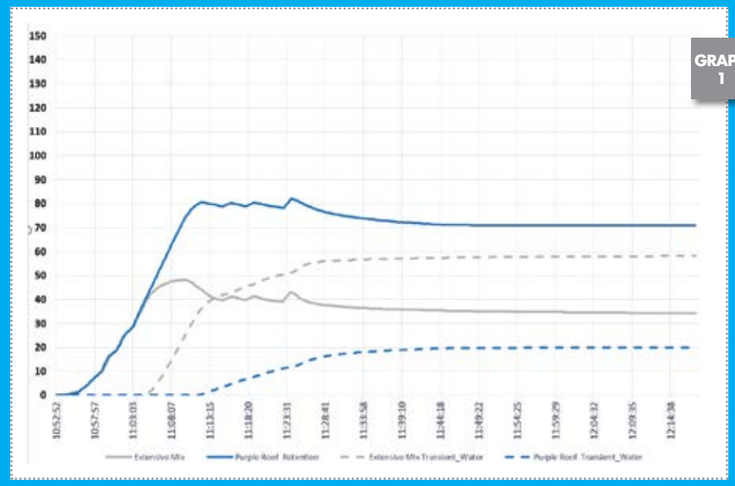
A new generation of mineral wool providing an alternative to the traditional variety has been invented and commercialized in the last decade. Bound together using a bio-based technology, this mineral wool is free from formaldehyde, phenols, and acrylics and uses no additional artificial colours, bleaches, or dyes. This reduces harmful manufacturing emissions and workplace exposures, improving the overall sustainability of buildings into which the product is incorporated.

However, as with traditional mineral wool, bio-based binders render the mineral fibres hydrophobic. A hydrophilic agent must be added to improve the hydrophilic capacity of the material. While mineral wool with bio-based binders will retain more water than phenol-based mineral wool, its long-term water absorption capacity decreases, as it does with the phenol-based variety, due to the flushing of the hydrophilic agent during periods of drought and precipitation.

Needled or binderless innovation

The most recent advancement in this industry is the manufacture of needled mineral wool—a non-petroleum-based and formaldehyde-free alternative. The needling process provides dimensional stability without the use of any binders—mineral wool is formed by a mechanical interconnection of pure mineral fibres.

This process forms a structurally stable, lightweight, and porous material with longer fibres that can maintain excellent water-holding properties. It is consistently hydrophilic, even after varying weather cycles throughout the year. The material can hold 90 per cent of its volume in water. When wet, the majority of the retained water is easily available for plants' uptake.[4] A minimum of 10 per cent oxygen is left in the needled mineral wool, enough to support the oxygen levels in the root zone and, therefore, healthy roots. The material is inert, with chemically stable fibres. On the left side of Figure 1, the condition of fibres three years after installation is shown with soil particles attached.



Needled RMW hydrophilic characteristics have long-term stability, as nothing rinses away. The physical attraction between fibres and water remains the same throughout the lifetime of the product.

This material is ideal for vegetated roofs, as it:

- is lightweight;
- can supplement or, in some cases, replace heavy growing media;
- can act as a water reservoir and support plant health;
- contributes to an 8 additional points towards LEED v4 (SS - Protect or restore habitat, SS - Open Space, SS - Rainwater Management, SS - Heat Island Reduction, EA - Optimize Energy Performance, MR -Environmental Production Declarations, EQ - Thermal Comfort, and EQ - Acoustic Performance)
- performs exceptionally and reliably as a rooftop stormwater management tool throughout the lifespan of the vegetated roof as seen on Sweden's Karolinska University Hospital, one of the largest university hospitals in Europe, Rentenversicherung HQ in Berlin and on projects throughout Baltic and Scandianvian countries.

Needled mineral wool is available as a **hydro blanket** with a density of 130 to 145 kg/m³ (286 to 319 lb/35 cf). It also is available as **hydro cubes** (20 mm x 20 mm [0.8 x 0.8 in.]) and as **hydro flocks** (3 to 20 mm [0.1 to 0.8 in.]). Cubes and flocks are added to a traditional growing medium and contribute to better soil structure, water-holding capacity, and aeration. The retained rainwater inside the hydro cubes or hydro flocks is easily available for plant uptake, improving plant survivability. Cubes and flocks are especially recommended for patios, terraces, and landscaping applications.

Research and analyses

As the needled manufacturing process does not require binders, it ensures the product's natural hydrophilicity remains intact, making it highly reliable for long-term stormwater management performance in vegetated roofs. When it comes to long-term water absorption, research shows needled mineral wool designed for growing plants outperforms traditional horticultural RMW by up to three times. Water uptake (WOK) analysis is used to determine this. This method shows the velocity of water absorption in time for specific substrates. After saturating and drying out, the capacity of absorption is measured for 1500 minutes. The results show long-term water absorption of needled mineral wool for growing plants is 70 per cent, whereas traditional phenol-based horticultural mineral wool absorbs significantly less—between 20 and 35 per cent.[5]

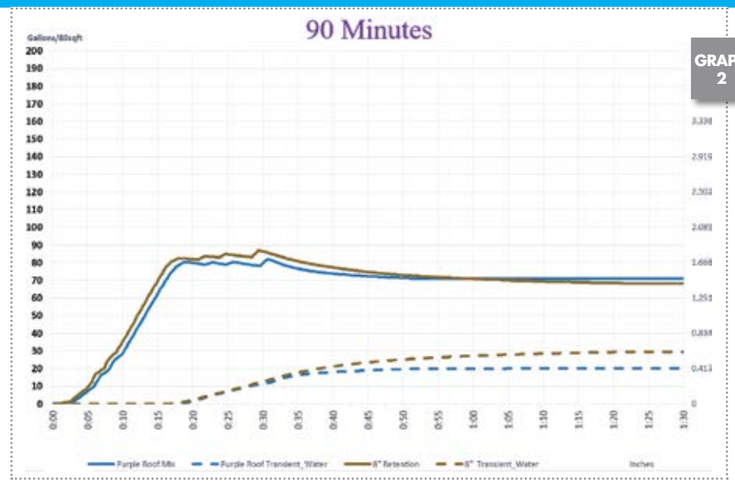
As experience and numerous studies show, RMWs using binders are commonly recognized as products for hydroponic growing, and the needled or binderless type—due to its unique characteristics—is ideal for outdoor environments. For example, it can be used in vegetated roofs for significant improvement of stormwater performance and roof longevity in different climate zones.

Research indicates RMW positively influences plant growth and development on vegetated roofs as well as in other applications.[6] It also showed great potential in container substrates as an alternative growing medium in the 1990s.[7] Applications of the new generation of needled RMW confirms this finding.[8]

Vegetated roofs constructed with binder-free needled mineral wool are tested and have been applied in various climate zones from moderate to extreme. Going forward, the focus continues to be on stormwater performance in retention testing, where vegetated roofs with a needled mineral wool layer are compared to traditional, engineered-growing-media-based vegetated roofs. Our stormwater testing laboratory in Virginia uses custom technology to apply replicable computerized rain events mimicking real-life rain events to evaluate assemblies 7.5 m² (80 sf) in size.

Inn Graph 1, the quantity of water retention and transient water is shown as measured on those samples in 90 minutes. Full and dotted blue lines represent the values for a vegetated roof with a binder-free needled mineral wool layer, which is nearly doubled in stormwater performance compared to a 101-mm (4-in.) vegetated roof with traditional engineered growing media only (shown with grey full and dotted lines in Figure 5). The mineral wool layer does not significantly affect the dynamics of the release, but strongly influences the quantity.

The second graph indicates stormwater performance is equivalent between a 101-mm vegetated roof with a needled mineral wool layer to which 272.5 L (72 gal) is applied after 90 minutes (again, shown with blue full and dotted lines) and a 203-mm (8-in.) vegetated roof without a mineral wool layer (with 257 L [68 gal] applied after 90 minutes). Introducing the needled mineral wool layer on the roof leads to significant load savings and the possibility of applying this solution when retrofitting.[9]



Conclusion

Technological developments in needled or binderless mineral wool have focused on increasing water retention and maintaining long-term performance. Needled mineral wool's characteristics better support root growth and overall plant health in various climatic zones, from hot and arid to frigid and wet, whether used in indoor applications such as urban farming or outdoor applications such as landscaping or vegetated roofing. Having been used in Europe for the past decade - with the largest of projects in Scandinavia, the Baltic States and Germany - needled mineral wool has recently become available in also in North America providing designers and engineers a viable solution to landscaping in arid areas, and increases the storm water management capacity on rooftops where it would otherwise be impossible.

Notes

1. For more, read the 2002 article, "Substrates and their Analysis" by M. Raviv et al., published in D. Savvas and H. Passam's *Hydroponic Production of Vegetables and Ornamentals* by Embryo Publications in Greece.
2. Further information on mineral wool production can be found in B. Širok et al.'s 2008 publication *Mineral Wool Production and Properties* from England's Woodhead Publishing Limited.
3. From Kowatsch's "Mineral Wool Insulation Binders," published in *Phenolic Resins: A Century in Progress* from 2010.
4. This was tested by pH curve. The authors can provide data upon request.
5. Water Uptake Anaylsis (WOK), test method developed by Regeling HandelsPotgronden, (RHP), Netherlands.
6. From D. Majkovič et al.'s 2016 presentation, "Promote Vegetated Roof Stormwater Performance with Mineral Wool Layer," from Cities Alive in Washington D.C. this past November. Also from C. Arkar et al's 2015 publication, "Lightweight Green Roofs' Thermal Response Under Freezing Conditions," from Energy Procedia 78.
7. The study that determined this can be found in W.C. Fonteno and P.V. Nelson's *Physical Properties of and Plant Responses to Rockwool-amended Media*, published in 1990 by the Journal of the American Society for Horticultural Science.
8. See the presentation in note 5. Also see A. Šušek et al's presentation from Ramiran 2015 at the Hamburg University of Technology, "The Impact of Rock Mineral Wool on Water Retention in a Conventional Growth Medium, and Development of Zonal Pelargoniums."
9. One cubic metre of the mineral wool layer weighs approximately 10 times less than the same amount of soil (110 kg [242 lb] versus 900 to 1200 kg [1984 to 2645 lb]).

Why green roofs should be designed as climate-sensitive stormwater solutions

Most urban conurbations contain large areas of paved or constructed surfaces which prevent stormwater from being absorbed into the ground. The resulting runoff can pollute and damage waterways and lead to flooding. One of the benefits of green roofs is their ability to help reduce stormwater pollution and flooding. Green roofs can reduce the flow of stormwater from a rooftop by up to 65% and slow the rate of runoff by up to three hours.

However, the efficiency of green roofs varies from one rainfall to another, and is dependent on climatic conditions and the specific design of the roof. This makes it difficult to provide broad statements on the stormwater performance of a green roof.

Green roofs are increasingly used as an official regulatory tool for stormwater management

Urban planners are beginning to specify green roofs within local and regional policies and are making them a mandatory element of many new builds. Therefore, understanding how a green roof should be designed to meet the required performance of is of paramount importance.

CLIMATIC CONDITIONS THAT AFFECT STORMWATER PERFORMANCE

1 SOLAR RADIATION
transforms water from liquid into gas – so it is triggering evaporation of water escaping from the green roof surface.

2 TEMPERATURE
and solar radiation are connected. At the same time as the solar radiation is warming the surface of green roof it is also warming the air around it. In general, the higher the air temperature, the greater the evaporation as warmer air is able to hold more water vapour.

3 RELATIVE AIR HUMIDITY
usually stated in %. So 50% means that air holds 50% humidity out of 100% capacity. When 100% is reached then air can no longer hold additional water vapour and so it condensates in the form of rain.

4 WIND
Wind speeds up evaporation. This is because it continually replaces the humid air above the evaporation area (the green roof surface) enabling additional evaporation to take place. This is why evaporation rates from green roofs are generally much higher than from regular gardens. The higher the speed of the wind, the greater will be evaporation as the humid air will move away faster.

5 RAIN
If you have continuous or heavy rain, then the green roof will not be able to dry out and make space for new rainwater within the green roof substrate. When the green roof becomes fully saturated rainwater will simply run through the substrate and into the sewage.

Role of Urbanscape® PET (Performance Evaluation) Tool

The Urbanscape® PET makes it much easier to design and construct perfect green roofs because it uses modelling to determine average rain water management performance, taking into consideration all key climate parameters and how they work together.

As a base for the key climate parameters for a green roof design, we use a reference year which is an average of more than 20 years' historical climate data.

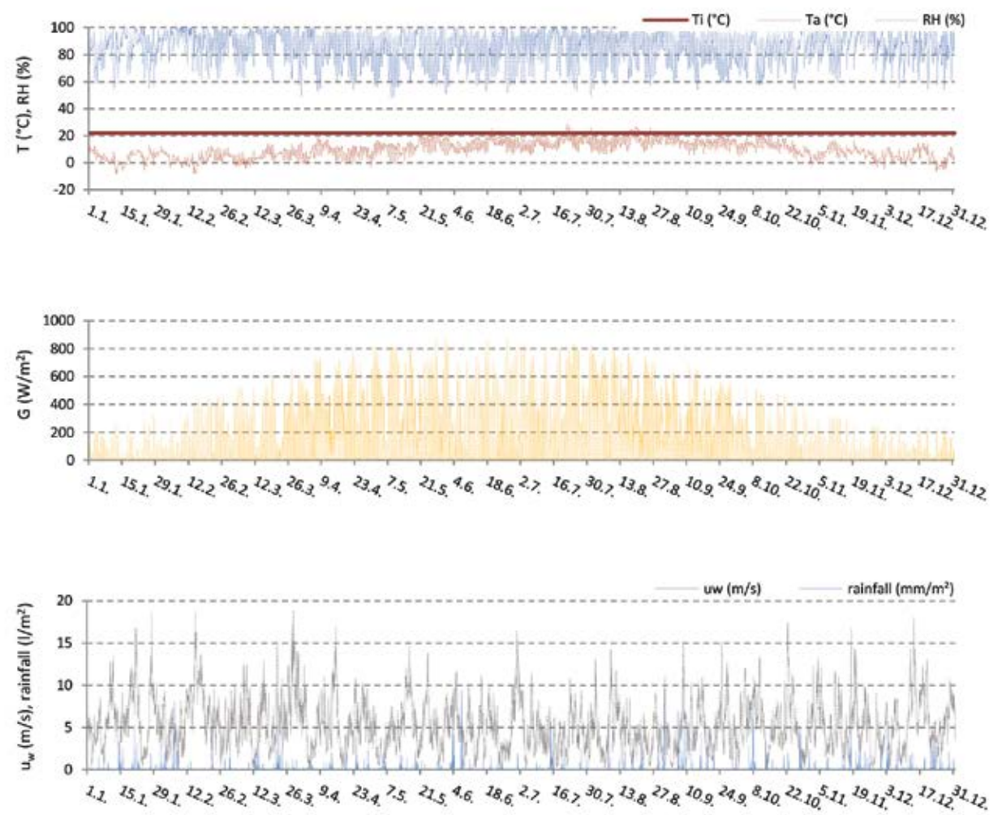
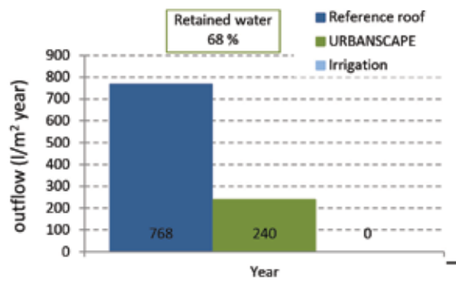


TABLE 1 Reference year climate data for Rotterdam, NL,

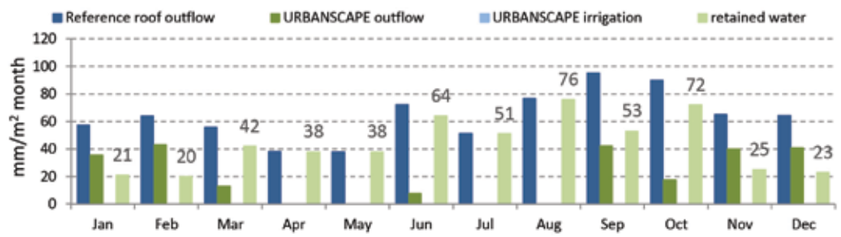
Using the same computer modelling we are able to design a roof according to the specifications and performance requirements specified by the customer or the regulations.

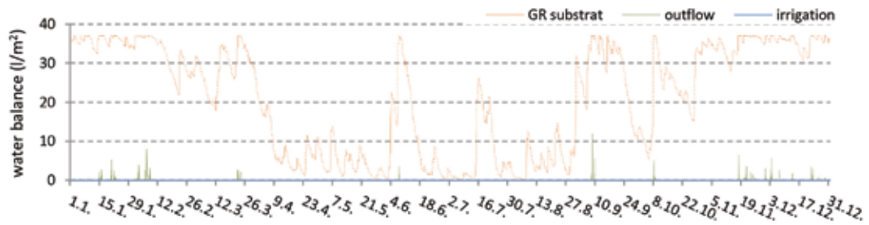
Example – Results for Urbanscape® Green Roof Premium (City of Rotterdam).

Results - water



	Irrigation (l/m²)	outflow (l/m²)	retained water (l/m²)	(%)
jan	0	36	21	37
feb	0	43	20	31
mar	0	13	42	75
apr	0	0	38	99
may	0	0	38	100
jun	0	8	64	89
jul	0	0	51	99
aug	0	0	76	99
sep	0	42	53	56
oct	0	18	72	80
nov	0	40	25	38
dec	0	41	23	36
Year	0	240	523	68





Adapting Green Roof Design

BASED ON THE CLIMATOLOGICAL DATA, SEVERAL DESIGN ELEMENTS CAN BE ADAPTED OR INCLUDED TO IMPROVE WATER RETENTION / HOLDING CAPACITY OF THE GREEN ROOF SYSTEM BY:

- developing highly absorbent green roof growing media
- increasing the thickness of growing media (the main limitation is usually the weight of the growing media)
- selecting types of plants that are able to absorb more water during the rainy seasons and
- developing / constructing innovative types of drainage systems (although with this element we are entering into the "blue roof industry")

By understanding the effect of the climatic conditions and design elements of the green roof we can then further optimise and ensure the performance of green roofs, not only with regards to rainwater management, but also with regards to heat island effect mitigation and energy savings.

WHY Urban Heat Island UHI Reduction is critically important – and how Green Roofs can help

URBANISATION GROWTH RATE CONTINUES TO INCREASE

The urban population of the world has grown rapidly from 746 million in 1950 to 3.9 billion in 2014. In 2014, the United Nations Department of Economic and Social Affairs (DESA) published a revised version of the World Urbanization Prospects. According to the report, 54 per cent of the world's population today lives in urban areas, a figure that is expected to rise to 66 per cent by 2050.
Projections indicate that with the current rate of urbanization combined with overall global population growth, the world's urban population could surpass 6 billion by 2045 and reach as much as 6.4 billion adding a total 2.5 billion more people to the world's urban population inside the next 35 years.
"Managing urban areas has become one of the most important development challenges of the 21st century. Our success or failure in ***building sustainable cities*** will be a major factor in the success of the post-2015 UN development agenda," says John Wilmoth, Director of the UN's DESA Population Division.

WITH URBANISATION COMES THE URBAN HEAT ISLAND (UHI)

Urbanization negatively impacts the environment, especially with the generation of big ***Urban Heat Islands***. UHI is defined as the rise in temperature of any man-made area, in comparison to more rural or green areas or other natural habitats. According to many studies, UHIs negatively impact not only residents of urban environs, but also other people and their associated ecosystems located far from the world's cities. In fact, UHIs have been indirectly connected to climate change because of their contribution to the greenhouse effect, and therefore, to global warming.
According to the report "Urban heat islands," prepared by the Met Office, the UK's National Weather Service, the 2003 heatwave across Europe is estimated to have resulted in additional 35,000 deaths, the majority of them in major towns and cities. It can't be determined exactly how UHIs contributed to that, but one thing is clear – every summer cities are becoming increasingly hotter, regularly breaking heat records for "downtown" areas.

GREEN ROOFS ARE HELPING, AREN'T THEY?

Cooling the outside surfaces of buildings should be a priority of all municipal areas around the world, and Green Roofs should become one of most common tools with which to fight UHI. Therefore, understanding how vegetated roofs can cool roofs down is of paramount importance.

Green Roofs on buildings can dramatically change the temperature on roofs, by converting old "heat radiator roofs" into cool green areas. The findings also confirm that there are certain elements that can drastically improve the positive effects of Green Roofs on UHI.

The two most critical elements you need to study in-depth to understand how and why green roofs are affecting real performance:

1 SHADING

- Plants provide good shading effects as well as reflect radiation from the sun;
- Without plants, this component of UHI reduction is eliminated – having healthy green roofs is key.

2 MOISTURE CONTENT IN GREEN ROOF

- Plants, together with growing media, capture a certain amount of water, which is the basis by which evapotranspiration takes place, reducing air temperatures and generating a net cooling effect on the surroundings.
- Evapotranspiration positively effects UHI reduction, as long as the Green Roof and plants still contain some moisture.

In order to see the effect of a Green Roof solution on the reduction of roof temperatures have a look at the comparison below, of two roofs / green roofs in Barcelona, Spain, but with one important difference:

- The first is non-irrigated;
- The second was designed with sub-ground drip irrigation, which was running when the moisture content dropped below a certain predefined level.

Non-irrigated roof

A simple glance at the chart shows that the average green roof performs far better than the traditional "Barcelona-type" flat roof; however, it loses its performance advantage when it dries out entirely.

In Barcelona, this can actually happen, as there is simply not enough rain during the hottest and driest months, like the summer months of June, July and August. During those months the green roof still performs, on average, better, but the difference is smaller than one would expect. If the difference in temperatures in May between a regular flat roof (temperature on the roof surface up to 70ºC / 158F) and the green roof (temperature on the green roof surface up to 40ºC / 104F) was still 30ºC / 54F, this difference can be dramatically lower for the month of August.

In the worst case scenario, when the green roof has dried out entirely, and vegetation is largely dormant, leaving a lot of unshaded ground, the difference in roof temperatures has diminished dramatically, even entirely.

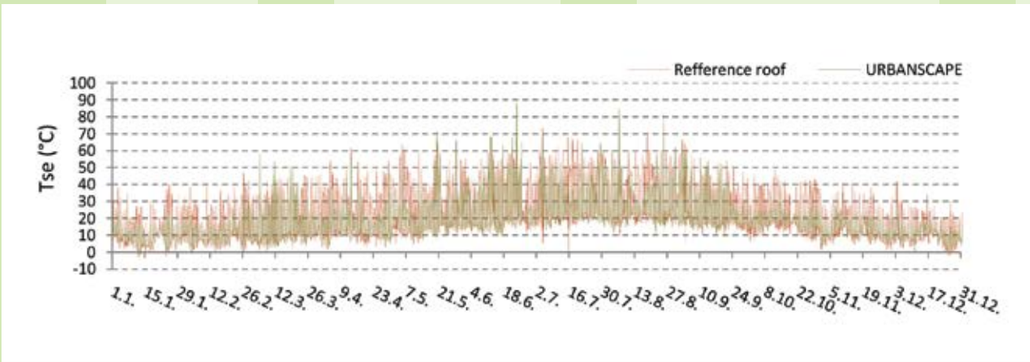


CHART 1 **Reference roof & Urbanscape® green roof temperatures**

Green Roof Benefit

Cleaner air

The plants on green roofs can also capture airborne particles such as smog, heavy metals and volatile organic compounds from the local atmosphere which has a positive effect on air quality and health of inhabitants. **Researchers estimate that 1m² of a green roof can help to absorb 0.2kg of airborne particles from the air every year****.

Natural habitat

As urbanisation increases, ensuring biodiversity is one of the key requirements for local councils. Green roofs can provide a habitat for various species and restore the ecological cycle disrupted by urban infrastructure.

Energy efficiency

Green roofs help to **reduce energy consumption by 25% for heating and 75% for cooling.***
With rising energy prices lower heating and cooling costs become increasingly appealing.

Irrigated roof

On the other hand a quick glance at the irrigated roof shows an entirely different picture.

It is clear that an irrigated roof performs far better in terms of temperature reduction on the roof. Even in the hottest, driest month – which in Barcelona is August – the temperatures on a regular "Barcelona-type" roof have easily exceeded 75 degrees C (167 F), whereas the green roof has barely reached 40 degrees C (104 F).

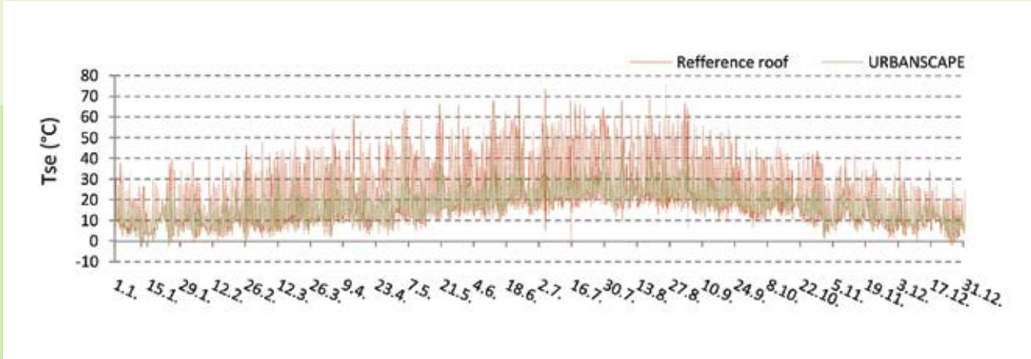


CHART 2 **Reference roof & Urbanscape® irrigated green roof temperatures**

The University of Ljubljana, together with the Urbanscape® team, have included the Urbanscape® Green Roof UHI performance evaluation in the **Urbanscape® Performance Evaluation Tool (PET).** The Urbanscape® PET therefore helps us design Urbanscape® green roofs and define irrigation protocols for them, with the aim of reaching maximum UHI reduction potential.

6 facts why Sedum plants are the best option for extensive Green Roofs

Green roofs are acknowledged as a premier example of multifunctional urban design. Wherever buildings are constructed, microhabitats are usually disrupted. The architects had adopted the philosophy of "footprint replacement," whereby green space lost through development is re-established on the roof (Grant, 2006).

Green roofs, like other constructed ecosystems (e.g., sewage treatment wetlands, bio swales for storm-water management, or living walls), mimic natural ecosystems to provide ecosystem services.

MORE GREEN ROOFS ARE OUR AIM... SO IS DIVERSE PLANTING AND LOCAL / NATIVE PLANTS CORRECT APPROACH FOR EVERY ROOF?

Planting native plants can in some situations be done successfully. But selecting and obtaining the right plants can be difficult and time consuming. Often, even if such plants are properly identified and available in the marketplace, they struggle in the harsh conditions on the roof. Even in a garden at grade, using native plants to improve ecological function and provide habitat is not simply a matter of choosing a few natives and adding them to the plant list. Restoration ecology requires scientific expertise and knowledge of horticulture, biology, soil science, climate, hydrology and how the characteristics on a site interact. On a roof, there is nothing to restore (McIntyre, Snodgrass, 2010).

Further, wide variety of plant species on the roofs usually require deeper growing medium, which contributes to the weight load and often building statics inhibits such load which consequently leads to less green roofs.

WHAT EXTENSIVE GREEN ROOFS SHOULD BE AND WHAT THEY DO FOR URBAN HABITAT

Vegetation on green roofs must be adapted to the harsh environment on the roof. Extensive green roofs usually have thin, coarse mineral-based growing medium and are planted primarily with sedums and other tough, drought-resistant, low growing plants.

Such plants are in most cases commercially available, easy to install and likely to survive if given the proper attention during the establishment period. Plants will spread and provide the vegetated cover necessary for optimal roof performance.

Six facts why Sedums are so appropriate...

1 CLIMATE ADAPTABLE

Many Sedum species are found in the northern hemisphere and particularly in the Mediterranean, but also in North Africa and South America, for instance, where Sedum is often found in dry and/or cold areas where water can be scarce. Sedum can store water in its leaves and is able to endure varying weather conditions (from -25°C and up to 40°C).

2 LOW GROWING MEDIA REQUIREMENT

Sedum has very shallow roots, which is necessary when the thickness of the growing media is limited, which is always the case on extensive green roofs. Suitability of low-growing *Sedum* species for use in extensive green roofs has been confirmed because of their superior survival in substrate layers as thin as 2 to 3 cm (Van Woert et al. 2005).

3 MODIFIED METABOLISM

At night sedum absorbs carbon dioxide and turns it into malic acid, which is used during the day for photosynthesis. The pores in the leaves only open at night, to minimize the loss of moisture during the hot, dry day.

4 HIGH DISEASE TOLERANT

There is also little or no incidence of disease or insect infestation in Sedum.

Several researches confirm high drought tolerance. Sedum Album (white stonecrop) could survive more than 100 day without water.

5 LOW WATER REQUIREMENT

Sedum is drought resistant and requires relatively little nourishment and maintenance as compared to other types of plants. While other species die from drought, Sedum is able to survive by adjusting its metabolism and saving on water supply. Sedum can recover very quickly as soon as it receives some moisture.

6 LOW MAINTENANCE REQUIREMENT

As Sedum is able to survive by adjusting its metabolism saving on water, this means that it also saves a lot on the food side. In general adding nutrients once per year is sufficient, but adding it 2 times, the Sedum will flourish.

Sedum Green roof is not always green in color

By having several sedum species in the blanket, this enables vegetation coverage through various seasons, and consequently the overall visual impression changes with the season. Many species have dormant periods during which the green roof may not appear so "green."

Asortiment on Urbanscape® green roofs can contain up to 12 species over time. In first two years, evergreen sedums dominate, while in later stage, big-leaf sedums grow and mature during the time. This composition is dynamic and varies. Flowering occurs mainly during the late spring and summer time.

SEE CASE OF EXTENSIVE URBANSCAPE® GREEN ROOF CHANGING COLOURS THROUGH THE SEASONS IN BELGIUM:

WINTER TIME

LATE SPRING / EARLY SUMMER

END SUMMER

AUTUMN

RESOURCES:

- Grant, G., 2006: Extensive green roofs in London. Published in: Urban Habitats. Green roofs and Biodiversity. Vol.4, no.1.
- McIntyre, L., Snodgrass, E.C., 2010. The Green Roof Manual: A Professional Guide to Design, Installation, and Maintenance
- Van Woert, et al., 2005. Watering regime and green roof substrate design affect Sedum plant growth. HortScience 40(3): 659-664.

4 MEASURES TO CONSIDER WHEN DESIGNING FIRE-SAFE GREEN ROOFS

Some 40 years ago the first truly extensive green roofs were built in Germany. Since then, green roofs have become a common addition to buildings. At the same time, this development has led to a more critical approach to fire safety. Related requirements are becoming increasingly strict, and will continue to evolve as green roof designs develop.

GREEN ROOFS SHOULD BE DESIGNED TO PROVIDE THE NECESSARY FIRE RESISTANCE

The first green roof performance tests, including fire tests, were performed and analysed in the 1990s. It's pretty safe to say that fire safety regulations differ, sometimes significantly, from country to country. So in order to gain a larger global perspective we need to review the way fire safety is treated and talked about on major green roof markets.

After reviewing many cases over the past few years, we can say that generally green roofs should be designed to provide the necessary resistance to the spread of fire by considering 3 primary measures:

1. The most cited measure is to increase the content of non-combustibles in the growing medium;
2. Lower the organic content of the growing medium;
3. Prevent the system from drying out; extensive roofs are not generally irrigated, therefore the risk of fire is mitigated by creating effective fire breaks and by reducing the organic content of the medium;
4. Last but not the least, fire safety can also be significantly improved by not employing highly combustible drainage elements (especially at the time of installation).

A number of guidance documents also refer to fire-resistant vegetative systems as "succulent-based" and "grass-based" systems – in both cases the growing media must contain at least 80% inorganic matter.

FIRE TESTING OF GREEN ROOF SYSTEMS

Classifications are set for testing methods for external exposure of fire to roofs.

The standard is based on the test methods contained in ENV 1187:2002. The test methods (t1, t2, t3 and t4) evaluate the fire performance of roofs/roof coverings under the following conditions:

1. test 1 assesses the performance of a roof exposed to burning branches
2. test 2 assesses the performance of a roof covering exposed to burning branches and wind
3. test 3 assesses the performance of a roof exposed to burning branches, wind and supplementary radiant heat
4. test 4 assesses the performance of a roof using a two-stage test method involving burning branches, wind and supplementary radiant heat

CLASSES OF EXTERNAL FIRE PERFORMANCE FOR ROOFS/ROOF COVERINGS:

TEST METHOD	CLASS	CLASSIFICATION CRITERIA
ENV 1187:2002 test 1	B_{ROOF} (t1)	All of the following conditions shall be satisfied for any one test: – external and internal fire spread upwards < 0,700 m; – external and internal fire spread downwards < 0,600 m; – maximum burned length external and internal < 0,800 m; – no burning material (droplets or debris) falling from exposed side; – no burning/glowing particles penetrating the roof construction; – no single through opening > 25 mm²; – sum of all through openings < 4500 mm²; – lateral fire spread does not reach the edges of the measuring zone; – no internal glowing combustion; – maximum radius of fire spread on 'horizontal' roofs, external and internal < 0,200 m.
	F_{ROOF} (t1)	No performance determined.
ENV 1187:2002 test 2	B_{ROOF} (t2)	For both test series at 2 m/s and 4 m/s wind speed: – mean damaged length of the roof covering and substrate < 0,550 m; – max damaged length of the roof covering and substrate < 0,800 m.
	F_{ROOF} (t2)	No performance determined.
ENV 1187:2002 test 3	B_{ROOF} (t3)	TE ≥ 30 min and TP ≥ 30 min.
	C_{ROOF} (t3)	TE ≥ 10 min and TP ≥ 15 min.
	D_{ROOF} (t3)	TP> 5 min.
	F_{ROOF} (t3)	No performance determined.
ENV 1187:2002 test 4	B_{ROOF} (t4)	– No penetration of roof system within 1 h. – In preliminary test, after withdrawal of the test flame, specimens burn for < 5 min. – In preliminary test, flame spread < 0,38 m across region of burning.
	C_{ROOF} (t4)	– No penetration of roof system within 30 min. – In preliminary test, after withdrawal of the test flame, specimens burn for < 5 min. – In preliminary test, flame spread < 0,38 m across region of burning.
	D_{ROOF} (t4)	– Roof system is penetrated within 30 min but is not penetrated in the preliminary test. – In preliminary test, after withdrawal of the test flame, specimens burn for < 5 min. – In preliminary test, flame spread < 0,38 m across region of burning.
	$ER_{ROOF}F$ (t4)	– Roof system is penetrated within 30 min but is not penetrated in the preliminary test. – Flame spread is not controlled.
	F_{ROOF} (t4)	– No performance determined.

Source: European Committee For Standardization, Fire classification of construction products and building elements

WHAT ABOUT IN GERMANY?

As the Germans were the first to implement modern green roof designs we had a special look at Germany. **The requirements of the German market were defined particularly strictly by federal state building ordinances, which require that building products meet a fire class rating of at least E** (*normal entflammbar*), except in cases where the application itself is contributes to reducing the spread of fire of non-classified, "easily combustible" (*leichtentflammbar*) products such that it performs like an E class-rated product according to EN 13501-1. All unrated products must be treated as "easily combustible".

Generally speaking, this means that **Green Roof Systems for Germany need to be designed with all of the elements having an E fire class rating**, regardless of the fire performance tested for the full Green Roof System.

In practical applications this means that every single Green Roof layer delivered separately to the roof needs to have E-Class certification according to the European Fire Class norm.

Most people from the green roofing industry don't take this as a risk, question this kind of approach, and don't even respect it. However, coming from the building industry and as a member of the Fire Safe Europe alliance, we can point to but a single, simple reason that **respecting fire safety guidelines is important.**

When the layer that is easily combustible is delivered to the roof during construction, it represents a huge risk of eventual fire and the spread of such. It poses a risk for the newly-built building itself, but even more of a risk if the green roof is being erected on an existing building where residents are already present. Many lives could be at stake, so **we from the Green Roof Industry must take such regulations seriously** and not try to avoid them.

In Europe, **Fire Safe Europe** Association and its partners from the building industry are calling for a holistic, coordinated approach to these issues through the implementation of a European Union Fire Safety Strategy. We strongly believe that harmonised fire tests and classification schemes for Green Roof Systems across all EU countries and beyond, based on the same testing methods at appropriate scales and representing all possible risk scenarios is something toward which we should we should all be aiming.

Presently, we are all working amidst a patchwork of different fire testing requirements – and this is bad news for fire safety.

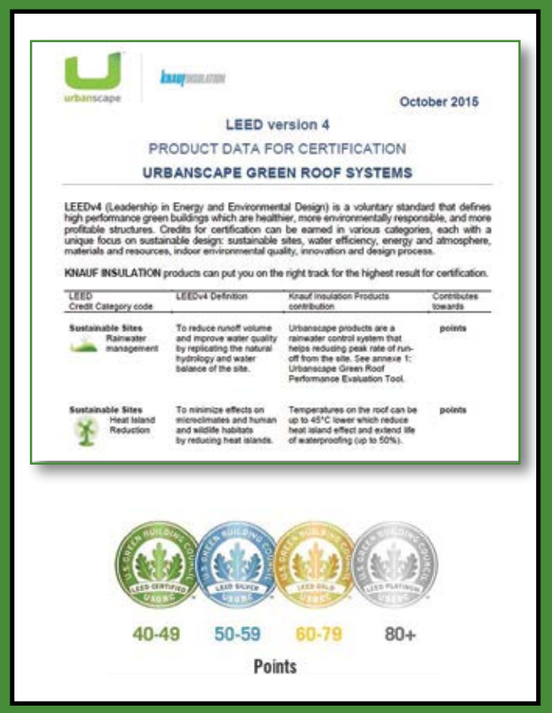
SOURCE:
- Jörg Breuning, Green Roof Service LLC – Green Roof Technology
- UK Government, DCLG, Fire Performance of Green Roofs and Walls
- Research Society for Landscape Development and Landscape Construction, FLL–"Guidelines for the Planning, Construction and Maintenance of Green Roofing – Green Roofing Guideline"
- European Committee For Standardization, Fire classification of construction products and building elements

Urbanscape® Green Roof System:
Lightweight car park, Halle Salle, Germany

Urbanscape® Green Roof System:
Deutsche Rentenrversicherung Bund, Berlin, Germany

HOW GREEN ROOFS CONTRIBUTE TO FINAL GREEN BUILDING RATINGS

The green construction industry is moving fast, together with a growing trend for Green Building Rating Tools. There are many different Green building assessment initiatives, with the two most popular outlined below:



October 2015

LEED version 4

PRODUCT DATA FOR CERTIFICATION

URBANSCAPE GREEN ROOF SYSTEMS

LEEDv4 (Leadership in Energy and Environmental Design) is a voluntary standard that defines high performance green buildings which are healthier, more environmentally responsible, and more profitable structures. Credits for certification can be earned in various categories, each with a unique focus on sustainable design: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and design process.

KNAUF INSULATION products can put you on the right track for the highest result for certification.

LEED Credit Category code	LEEDv4 Definition	Knauf Insulation Products contribution	Contributes towards
Sustainable Sites Rainwater management	To reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site.	Urbanscape products are a rainwater control system that helps reducing peak rate of run-off from the site. See annexe 1: Urbanscape Green Roof Performance Evaluation Tool.	points
Sustainable Sites Heat Island Reduction	To minimize effects on microclimates and human and wildlife habitats by reducing heat islands.	Temperatures on the roof can be up to 45°C lower which reduce heat island effect and extend life of waterproofing (up to 50%).	points

40-49 50-59 60-79 80+

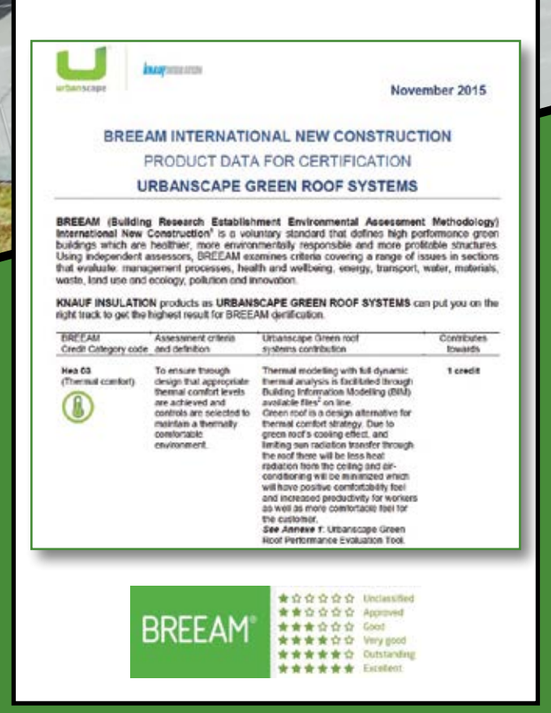
Points

LEED, or Leadership in Energy and Environmental Design, **is changing the way we think about the way buildings and communities are planned, constructed, maintained and operated. Leaders around the world have made LEED the most widely used third-party verification scheme for green buildings, with around 1.85 million square feet of built surface certified daily.**

Developed by the U.S. Green Building Council (USGBC), LEED started back in 1993 in the USA and is now popular not only in North America but worldwide. LEED works for all buildings and covers new, existing, commercial and residential properties, from homes to corporate headquarters, and is concerned with energy, atmosphere, water efficiency, materials, resources and indoor environmental quality.
LEED provides a point system to rate green building design and construction. The system comprises a possible total of 100 points. In order to be certified applicants need a score higher than 40; for Silver >50, for Gold >60, and for Platinum >80 points or more.
LEED-certified buildings are resource efficient. They use less water and energy and reduce greenhouse gas emissions. As an added bonus, they save money.

BREEAM or Building Research Establishment Environmental Assessment **Method was initiated in the UK in 1990, where it is now a voluntary initiative in the private sector and compulsory in the public sector. It is the world's leading sustainability assessment method for masterplanning projects, infrastructure and buildings, and addresses a number of lifecycle stages such as New Construction, Refurbishment and In-Use.**

Globally there are more than 540,700 BREEAM-certified developments, and almost 2,234,800 buildings registered for assessment since it was first launched in 1990.



November 2015

BREEAM INTERNATIONAL NEW CONSTRUCTION

PRODUCT DATA FOR CERTIFICATION

URBANSCAPE GREEN ROOF SYSTEMS

BREEAM (Building Research Establishment Environmental Assessment Methodology) International New Construction[1] is a voluntary standard that defines high performance green buildings which are healthier, more environmentally responsible and more profitable structures. Using independent assessors, BREEAM examines criteria covering a range of issues in sections that evaluate: management processes, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, pollution and innovation.

KNAUF INSULATION products as URBANSCAPE GREEN ROOF SYSTEMS can put you on the right track to get the highest result for BREEAM certification.

BREEAM Credit Category code	Assessment criteria and definition	Urbanscape Green roof systems contribution	Contributes towards
Hea 03 (Thermal comfort)	To ensure through design that appropriate thermal comfort levels are achieved and controls are selected to maintain a thermally comfortable environment.	Thermal modelling with full dynamic thermal analysis is facilitated through Building Information Modelling (BIM) available files[2] on line. Green roof is a design alternative for thermal comfort strategy. Due to green roof's cooling effect, and limiting sun radiation transfer through the roof there will be less heat radiation from the ceiling and air-conditioning will be minimized which will have positive comfortability feel and increased productivity for workers as well as more comfortable feel for the customer. See Annexe 1: Urbanscape Green Roof Performance Evaluation Tool.	1 credit

BREEAM

Unclassified
Approved
Good
Very good
Outstanding
Excellent

Points are awarded in line with sustainable approaches to energy and water use, internal environment, pollution, transport, materials, waste, ecology, management processes and the life-cycle of buildings. During the assessment process, each category is sub-divided into a range of issues, which promotes the use of new benchmarks, aims and targets. When a target is reached credits are awarded. Once the development has been fully assessed a final performance rating is granted, depending on the total number of credits awarded. A total of 109 credits are available, for which less than 30 is a Fail; a Good is 45, Very Good 55, Excellent 70 and Outstanding over 85.

Using Green Roof Systems in green buildings

Using green roofs earns points in different Green Building Rating Systems.

Urbanscape® Green roof systems installed on different types of buildings can put you on the right track to earning the highest BREEAM /LEED certification rating, with consideration of:

1 THERMAL COMFORT

Green roofs are a thermal comfort strategy design alternative. Due to a green roof's cooling effect, and limited sun radiation transfer through the roof there is less heat radiation from the ceiling and air-conditioning can be minimized, which has a positive effect on feel and comfort feel, makes for better productivity for people at work and makes conditions more comfortable for the customer.

2 ACOUSTIC PERFORMANCE

Systems mitigate indoor ambient noise originating from the roof.

3 ENERGY EFFICIENCY

Systems help reduce operational energy demand, primary energy consumption and CO_2 emissions by maintain appropriate temperatures through both the summer and winter seasons.

4 SUSTAINABLE SITE

Vegetated roofs are open spaces that deliver specific environmental benefits. The presence of green areas has a relaxing psychological effect, helps reduce blood pressure and lowers heart rates.

5 HEAT ISLAND REDUCTION

Temperatures on the roof can be reduced by up to 45°C, which reduces heat island effect and extends the life of waterproofing (up to 50%).

6 RAINWATER MANAGEMENT

Urbanscape® products are rainwater control systems that help reduce peak runoff rates on the site.

And much more…
Check how Urbanscape® Green Roof Systems contribute to LEED or BREEAM certification and download our Product Data from our website www.green-urbanscape.com

ENVIRONMENTAL PRODUCT DECLARATION

EPD

transparent declaration of the life-cycle environmental impact of green roof systems

Great, we have it – the first in the green roof industry – for the whole Urbanscape® Extensive Green Roof system. But what does it actually mean; and what are the benefits of having it? Read our blog and find out…

ENVIRONMENTAL PRODUCT DECLARATION
as per ISO 14025 and EN 15804

Owner of the Declaration	KNAUF INSULATION
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	EPD-KNI-20160071-CBA1-EN
ECO EPD Ref. No.	ECO-00000371
Issue date	30/05/2016
Valid to	29/05/2021

URBANSCAPE Extensive Green Roof System

KNAUF INSULATION

www.bau-umwelt.com / https://epd-online.com


© by Architect Kristof van Hoof – Zandhoven (B)

WHAT IS AN EPD – ENVIRONMENTAL PRODUCT DECLARATION?

In life-cycle assessment, an Environmental Product Declaration (EPD) is a standardized way **of quantifying the environmental impact of a product or system.**
Declarations include information on the environmental impact of acquiring the raw materials, energy consumption and efficiency, materials and chemical substances, emissions into air, soil and water, and waste generation. Product and company information is also included.

An EPD is **created and verified in accordance with the International Standard ISO 14025**, developed by the International Organization for Standardization (ISO). EPDs are based on a life-cycle assessment according to ISO 14040 and ISO 14044. It is an independently verified document that is based on the scientific principles of LCA (Life Cycle Assessment) and communicates the life-cycle environmental impact of the product.

WHY IS IT IMPORTANT?

One important role of the EPD is to **provide the basis for a fair comparison of products and services** according to its environmental performance. EPDs can reflect the continuous environmental improvement of products and services over time and are able to communicate and accumulate relevant environmental information along a product's supply chain.

The environmental impact of processes and materials are usually separated into the following life cycle stages:

- Upstream processes: includes raw materials, acquisition and processing/refining as well as the production of intermediate components
- Core processes: manufacturing processes
- Downstream processes including usage and end-of-life stages

An EPD may be used for many different applications, including green public procurement (GPP) and building assessment schemes.

IN SHORT: **An Environmental Product Declaration (EPD)** is a verified (and registered) document that communicates transparent and comparable information about the environmental performance of specific products or systems over their life cycle.

Urbanscape® is the first in the green roof industry to publish a System EPD (Environmental Product Declaration) for its Extensive Green Roof System.

The Urbanscape® Extensive Green Roof System is the perfect sustainable product for the entire building life cycle.
For architects and specifiers interested in Building Rating Systems such as BREEAM, LEED, DGNB or HQE, an Urbanscape® Green Roof System EPD can now provide points for categories such as 'product disclosure' or 'building life cycle'.

WHERE TO FIND AN EPD FOR THE URBANSCAPE® EXTENSIVE GREEN ROOF SYSTEM?

This system EPD, which is the first of its kind, is available for download on our website ***www.green-urbanscape.com****.*

Green Roof Benefit

Extended roof life
Green roofs have been shown to **triple the life expectancy of the roof.** The underlying roof materials are protected from mechanical damage, ultraviolet radiation and extreme temperatures, which results in reduced maintenance and renovation costs

10 SUPERIOR GREEN ROOF STORM WATER CONTROL DESIGNS SOON TO BE TESTED

The **Purple Roof "Enhanced by Urbanscape®"** concept, a joint effort between sedum grower Sempergreen from Virginia, in the USA, and binder-free mineral wool growing media supplier Knauf Insulation from Slovenia, EU (part of the German Knauf Group) is taking on a whole new dimension.

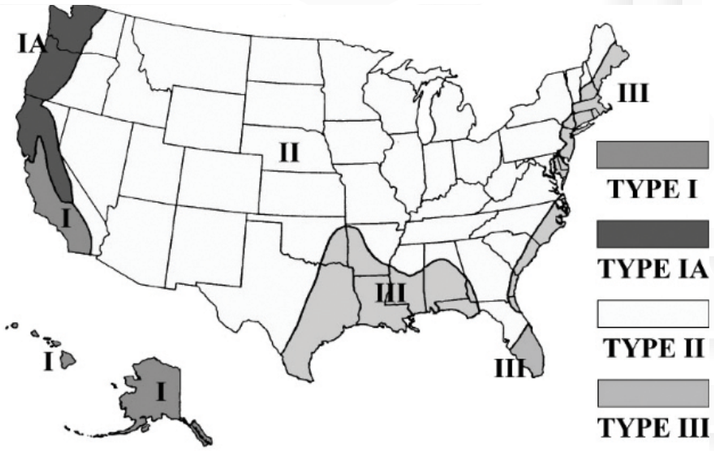
"Over the course of testing in past years we have found out so many new things that now we know how to modify the green roof design to optimize rain water control on the roof and to supply civil engineers with better information to do their work. We know exactly how to apply different growing media strategies to produce the best results. First, we see how to maximize storm water control, and when this is functioning satisfactorily we also compare how the plants grow according to the new designs. We have had more than 30 green roof designs set up on the premises since 2012, and we can see what works best in terms of appearance. "***Our goal is to provide the optimum combination of storm water management and green aesthetics,***" says Oscar Warmerdam, President of Sempergeen USA.

30 green roof designs set up and tested for storm water control and left to monitor plant performance and diversity through the seasons.

"We have been doing intensive storm water testing back in Europe for the past four years in order to better understand our unique Urbanscape® mineral wool growing media as part of the Urbanscape® Green Roof System. In North America, we are taking it a step further. We want to design a concept that is easy to apply across the wider green roof industry. We do not want to sell our own system on the market, but want instead to provide a concept that all of the major green roofers can use as their own – or as an addition to an already existing portfolio," says Jure Šumi, director of global business development for Urbanscape® Green Solutions.

The storm water lab, which was designed by Sempergreen USA in 2016 with support from Knauf Insulation, American Hydrotech, Firestone and Greenrise, has already been further upgraded now, in 2017. Many new additions have been made in order to simulate and repeat, with great precision, extreme storms that can last up to six hours.

There are currently four rainfall distribution zones in the USA, each with their own typical extreme rain events than can be now simulated in the storm water lab. **The Purple-Roof "Enhanced by Urbanscape®"** concept will be tested according to all four scenarios in order to gain accurate data on specific rainwater detention and retention characteristics during specific super storms typical for each of the four zones.



It might appear that this is a very general approach, but each region has a certain storm type, and within the storm type there are local intensity and volume values that apply – as we know that average rainfall differs from city to city, this is a common approach for civil engineers when planning storm water management measures.

The ultimate goal will be to custom design green roofs for every major city, taking into consideration:

- Maximum storm water retention and detention during a typical storm in order to prevent floods and pollution.
- Maximum annual storm water retention, in order to minimize the burden on sewage treatment facilities.

The Purple Roof concept is already in use at several American and Canadian green roofing companies, and by many others around the world. And more are starting to include the Urbanscape® Hydro Blanket and to modify their own existing systems for optimal storm water performance.

Green Roof Benefit

Natural look

The natural character of green roofs provides relief from the concrete construction in urban areas and introduces substantial changes to modern architecture. According to several studies the presence of green areas has a relaxing psychological effect, helps to reduce blood pressure and lowers the heartbeat. Due to multiple benefits, green roofs substantially enhance residential and commercial property values.

CASE STUDIES

1 Making life more comfortable for boathouse residents on the waterways of Amsterdam (Holland)

Sempergreen BV (NL) is using the Urbanscape® Green Roof System featuring Urbanscape® Green Roll and Sedumworld Sedum blankets to make life more comfortable aboard boathouses in Amsterdam.

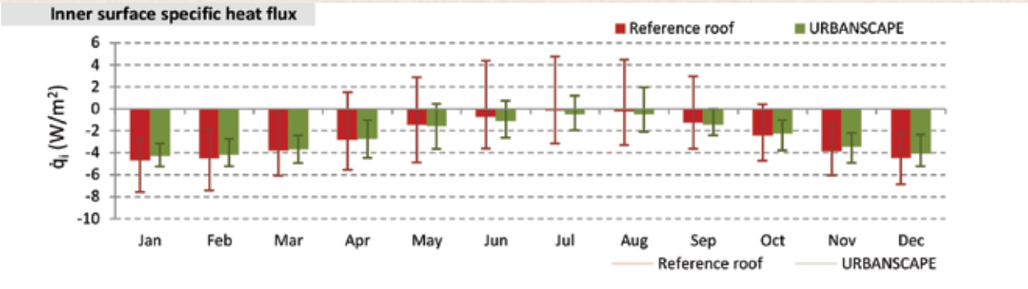
STANDARD BOATS – THE SUN RAISES INDOOR TEMPERATURES DURING SUMMER

These boats usually employ lightweight wooden roof constructions with a minimum of insulation. During the summer, the transfer of intense solar energy dramatically raises temperatures inside the boats.

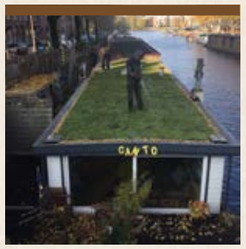
BOATS WITH GREEN ROOFS – MORE COMFORTABLE LIVING DUE TO LOWER HEAT AND SOLAR RADIATION LEVELS

The lightweight design of the Urbanscape® system in no way compromises overall structural stability, and at the same time serves as a good stormwater buffer, which works to cool the boat's roof through the natural process of evaporation. And during the growing season Sedum provides additional shade, further helping cool the roof and cabin interior below.

The difference in real surface specific Heat Flux can be seen from the chart below, which is calculated using climate data for Amsterdam. It's obvious that heat flux values can be expected to be dramatically reduced during peak periods.



Houseboats – each 80 sqm... / 4 already done... / In total 320 sqm... / For now!

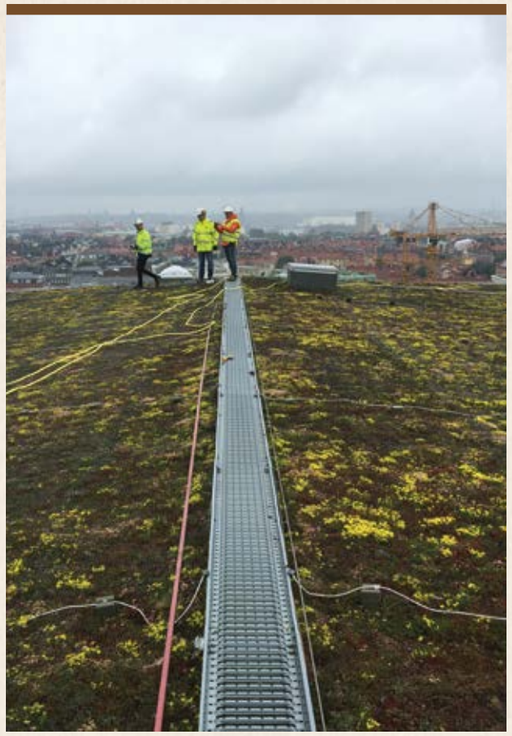


2 Light weight Urbanscape® Green Roof System Air concept on top of the Karolinska University Hospital (Sweden), world's biggest hospital

Karolinska University Hospital, situated just a few kilometers from the Swedish capital Stockholm, has 15,800 employees, 1,600 hospital beds and more than 4,400 patient visits per day. Standing next to the existing hospital, the "New Karolinska Hospital" is covered by **more than 20,000 m² of new green roofs**.

The green roof project was a joint collaboration between the Knauf Insulation Green Solution central team from Slovenia, Swedish Urbanscape® partner Sempergreen / Eurotema AB, and Swedish installer LW Sverige AB.

The **Sempergreen/Eurotema "enhanced by Urbanscape®"** green roof system has been designed specifically to meet the requirements of the Scandinavian markets, providing a base for healthy vegetation and at the same time providing advanced performance in terms of storm-water control and energy efficiency.



Urbanscape® Green roofs in Dubai (UAE) and Riga (Latvia)

3

Two borderline case stories, where customer needs particularly determined the type of green roof construction, and where employing a traditional green roof simply doesn't work.

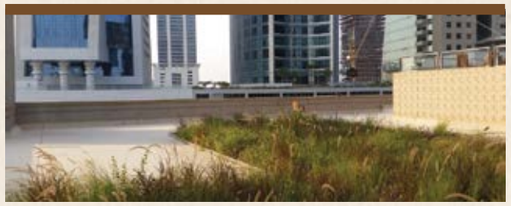
A GREEN ROOF, FIGHTING EXTREME HEAT AND HUMIDITY IN DUBAI (UAE)

And when we talk about extreme, we're talking about summer daytime temperatures that can easily exceed 50° C / 120° F...
The site in Dubai, where the Green Roof was installed back in 2016 is actually a roof on a four-storey building that connected two residential skyscrapers. The roof had been used as a recreational space where residents could meet and relax, either at a nice open bar/restaurant or by a nice pool. But, as it was paved entirely with concrete white paving stones it definitely lacked a bit of green space.

So the green roof might have been a good solution. There were a few main requirements on the investor's side:

- The green roof needs to be lush, so that residents will see it as a real field of flowers and grasses.
- The green roof should not be too heavy, as the area dedicated to installation of the green roof was actually a roof covering meeting rooms below.
- The green roof can be irrigated, but should not require more irrigation water than what the Dubai code specifies for parks and gardens.

Initially, this seemed too demanding a challenge to overcome. We had to design a green roof no larger nor greater than 60 kg/m² (12 lbs/ft), would not consume more than 8 litres/m² (0.3") of water per day in the highest summer months, and would continue to look lush and green. Just look at what we were able to develop using only 6 cm (2.5") of growing media, which weighed less than 50kg/m² (10lbs/ft) fully saturated.



A GREEN ROOF IN RIGA (LATVIA), WHERE WINTER TEMPERATURES CAN EASILY DROP WELL BELOW -20° C / -5° F.

Like the Dubai case, the Riga green roof was built in a residential area. The roof between the residential buildings was meant to be a recreational space, where families could hang out late in the afternoon and watch the kids playing in the rooftop-playground.
The simplest green roof structure using grass over the entire roof would have been the cheapest alternative; however, this would actually require a lot of maintenance over the years to come, which would be a burden for future residents, so this idea was initially scrapped.

The following requirements were drawn up for us to follow:

- The green roof needs to be fully vegetated on the day the first residents arrive.
- The green roof should remain nice, even in the colder winter months when not covered in snow.
- The green roof should require a minimum of maintenance and mean only low additional costs for the residents.
- The original design should make the roof thicker than the pathways made of concrete paving stones.
- The green roof must act as a storm-water management tool.

The vegetation part was relatively easy for us to comply with. The plants were selected by our global partner Sempergreen. The use of all year-round green sedum species – so-called creepers like Album coral carpet, Acre murale, Sexangulare and similar – were musts in order to comply with the year-round appearance requirement. They don't lose their leaves, but can turn a little reddish in extreme cold.

The difficult part here was to provide sufficient storm-water management with a thin structure that would not exceed the height of the pavers. This can't be done with regular green roof soil, so we used a structure that employed Urbanscape® Growing Media which just 4 cm thick (1.8"), yet could still hold the majority of the annual rainfall (more than 70%) that usually pours down on the roofs of Riga.

Once built and ready the entire place looked fantastic, and complied with all of the initial requirements.

Can railways and motorways be called green infrastructure?

4

At Urbanscape®, we think a lot about a greener future, and therefore offer special green infrastructure solutions called Green Designs on the Move™. One part of the solution is **green tracking**, with the aim of educating people about green urban infrastructure, why it matters and how it helps improve our living environments.

While a lot of people think it is complicated and expensive to restore existing infrastructure back to green infrastructure, it is actually not. This can be achieved with **low maintenance** green track systems that help enhance **emission protection** characteristics, are **easy to install** and are **less expensive** than conventional grey infrastructure.

HIGHWAY BELT ON A33 MOTORWAY IN GERMANY

At Urbanscape®, we customise each design to specific projects and specific climate zones. For example, in cooperation with Geotextile GmbH and Sempergreen, a green belt 9 km long between two highway tracks on A33 motorway close to Bielefeld in Germany was installed. Here the green belt is raised so that the salt doesn't reach the plants and destroy them.

Green Roof Benefit

Noise reduction
A green roof system provides good sound insulation, keeps the living space quieter and creates more pleasant surroundings in urban areas. It contributes to noise reduction in large cities, near industrial areas and airports.

Usable green space
Green roofs help to provide additional green space in urban areas with limited open space and add value to buildings. Accessible roofs can be designed as community gardens, commercial or recreational space allowing numerous use opportunities.

Urban agriculture
Green roofs can additionally create opportunities for urban agriculture. They can reduce a community's urban footprint thanks to local food system creation and ensure self-reliance on food resources.

Building Information Modelling (**BIM**) for extensive Urbanscape® Green Roof System

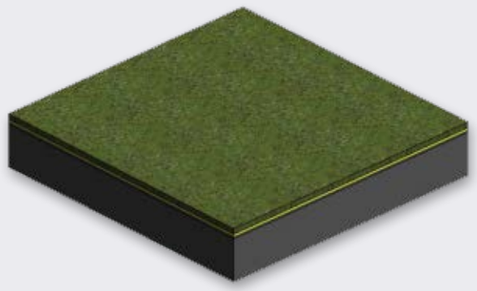
More than just piece of software or a tool…

BIM is a process involving the generation and management of a digital representation of the physical and functional characteristics of a facility. The resulting building information model becomes a shared knowledge resource that supports decision-making about a facility from the earliest conceptual stages, through design and construction, through to its operational life before its eventual demolition.

To assist and support the work of architects, engineers and other users Urbanscape® Green Solutions Team has developed a **detailed BIM object of Urbanscape® extensive green roof systems**, which includes all of the necessary geometric, material, physical and functional characteristics of several Urbanscape® systems and layers. With this parametric Urbanscape® BIM object users can quickly and easily design an extensive green roof, where not only is an accurate physical representation given but also all key green roof-related information, like static load, water retention, compressive strength, packaging etc., which is automatically integrated in the package without the need for additional technical documentation.

Our BIM object for Urbanscape® Green Roof System can be downloaded from our website
www.green-urbanscape.com

If you are interested in receiving a sample Performance evaluation report for a selected town or country, contact us via
urbanscape©knaufinsulation.com

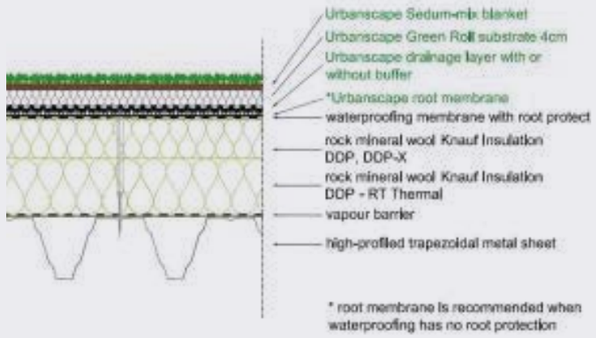


Detailed drawings (**CAD Designs**) for Urbanscape® extensive Green Roof system available now!

A set of several Urbanscape® extensive green roof system detail drawings was made to assist architects and other designers with their work.

CAD (Computer Aided Design) is a combination of hardware and software computer technology that enables designers (architects, engineers, etc.) to replace manual drafting with the precision of a digital process capable of creating 2D and 3D models, drawings and plans.
As this is the most widely used tool employed in architectural design a set of several Urbanscape® extensive green roof system detail drawings was made to assist architects and other designers with their work.

To download Urbanscape® CAD design, visit our website
www.green-urbanscape.com

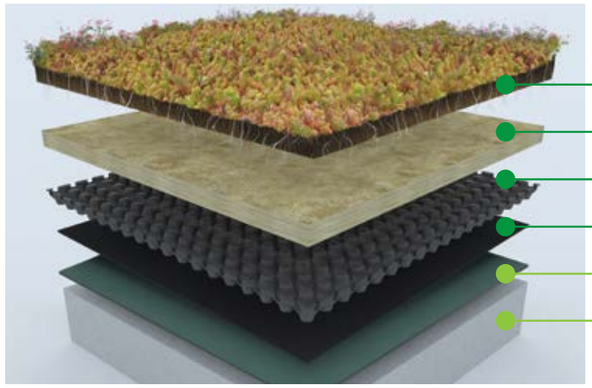


URBANSCAPE®

Fighting for better, greener, healthier environment

Urbanscape® Green Roof System

A complete, lightweight and easy to install system with **high water retention** capacity designed for green roofs on residential, non-residential and industrial buildings in urban areas.




Moda Deniz VIP Club, Turkey


Karolinska Hospital, Sweden

Green roofs: providing solutions designed to reduce urban heat island effect and manage storm water effectively and efficiently!

Urbanscape® Green Wall System

Lightweight, easy to install vertical planting system, specially designed for use in schools, hospitals, shopping malls, hotels, restaurants and office buildings.

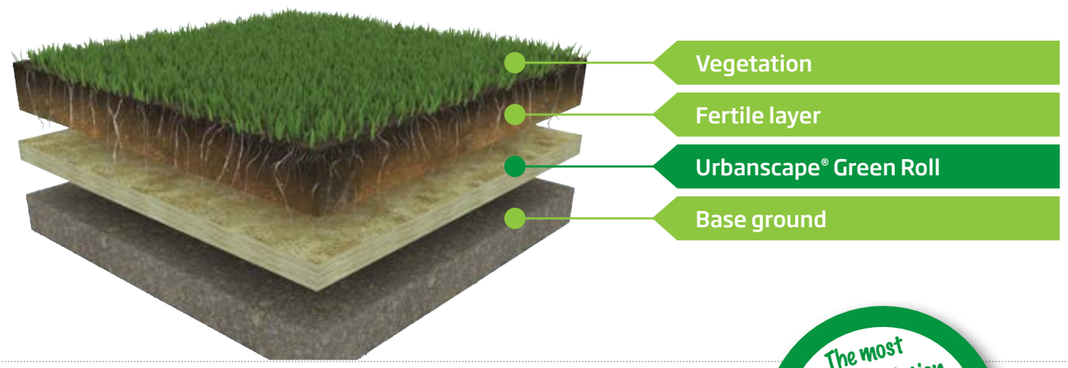
Making the world a bit greener every day!


Q-park Hague, Holland


Hyatt Regency Hotel Amsterdam, Holland

Urbanscape® Landscaping System

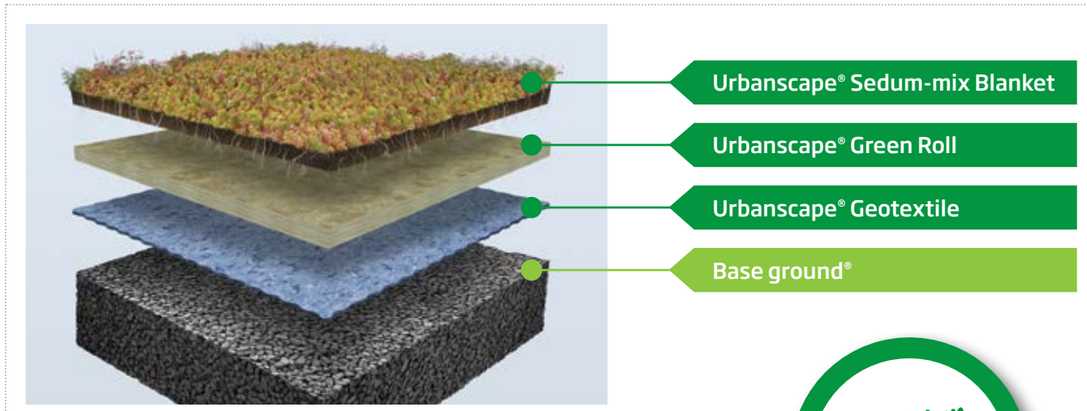
An innovative and easy to install system that boasts superior water absorption and **high water retention** capacity designed for various landscaping applications: residential gardens, sports fields, commercial spaces, cemeteries, public parks and more.



The most versatile solution for growing plants in highly demanding environments!

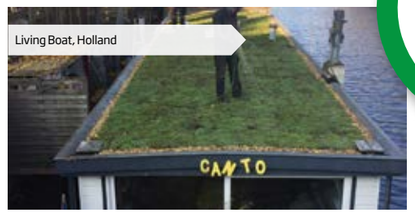
Urbanscape® Green Designs on the Move

An innovative conceptual vegetated design scheme that can:
- work as part of a transportation infrastructure (tracks, roads...)
- be implemented on vehicles (cars, trains, boats...)



Green Urban Infrastructure Matters!

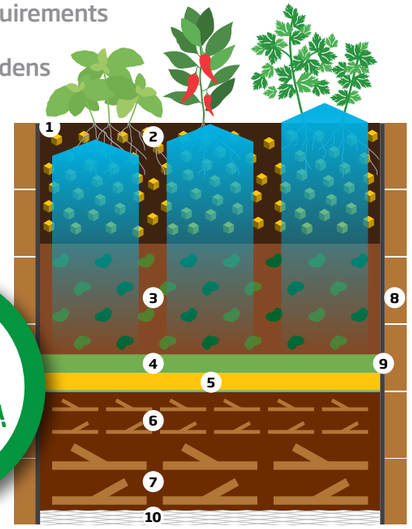

Autobahn 33, Germany


Living Boat, Holland

Urbanscape® Products for Raised Gardens

Grow more fresh and healthy vegetables in small spaces, with less effort and:
- **Retain moisture in the raised bed and thus reduce watering requirements**
- **Loosen the soil for better aeration**
- **Prevent leaching of nutrients into the lower layers of raised gardens**

1. Plant-based fertilizer for fruit and vegetables during periods of rapid growth
2. Fertile soil mixed with Urbanscape® Green Cubes for effective water storage
3. Compost
4. Grass clippings or straw
5. Urbanscape® Green Roll to retain moisture and prevent leaching
6. Thin branches
7. Thick branches
8. Frame (wood, stone, other)
9. Protective film
10. Protective mesh against voles



Save water and make sure plants stay healthy!

Urbanscape Green Roof System: Residential Villa in Brasschaaat (Belgium)
© by Architect Kristof van Hoof – Zandhoven (B)

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Let us know your comments or email us your questions at
urbanscape@knaufinsulation.com

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www.green-urbanscape.com

ABOUT KNAUF INSULATION

Knauf Insulation is one of the leading and fastest growing manufacturers of insulation materials; our mission is to become the world leader in energy efficient systems for buildings. Building on over 30 years of expertise in energy efficiency, we are focused on providing a comprehensive range of solutions for residential and non-residential buildings and industrial customers. We are committed to providing building materials that deliver real performance to improve sustainable construction; with the introduction of our new **Urbanscape® Green Roof System** we are delivering on this commitment.

Knauf Insulation is active in more than 35 countries with 37 manufacturing plants and over 5000 employees across the globe. The company, which is part of the German family-owned Knauf Group, continues its strong and steady operational and financial growth, having achieved a turnover well in excess of €1.6 billion in 2016.

KNAUF INSULATION d.o.o.
Trata 32, 4220 Škofja Loka, Slovenia
Phone: +386 (0)4 5114 000
E-mail: urbanscape@knaufinsulation.com

www.green-urbanscape.com