Facts & Values

Multifunctional Roofs

The struggle for urban space is resolved on the rooftops.

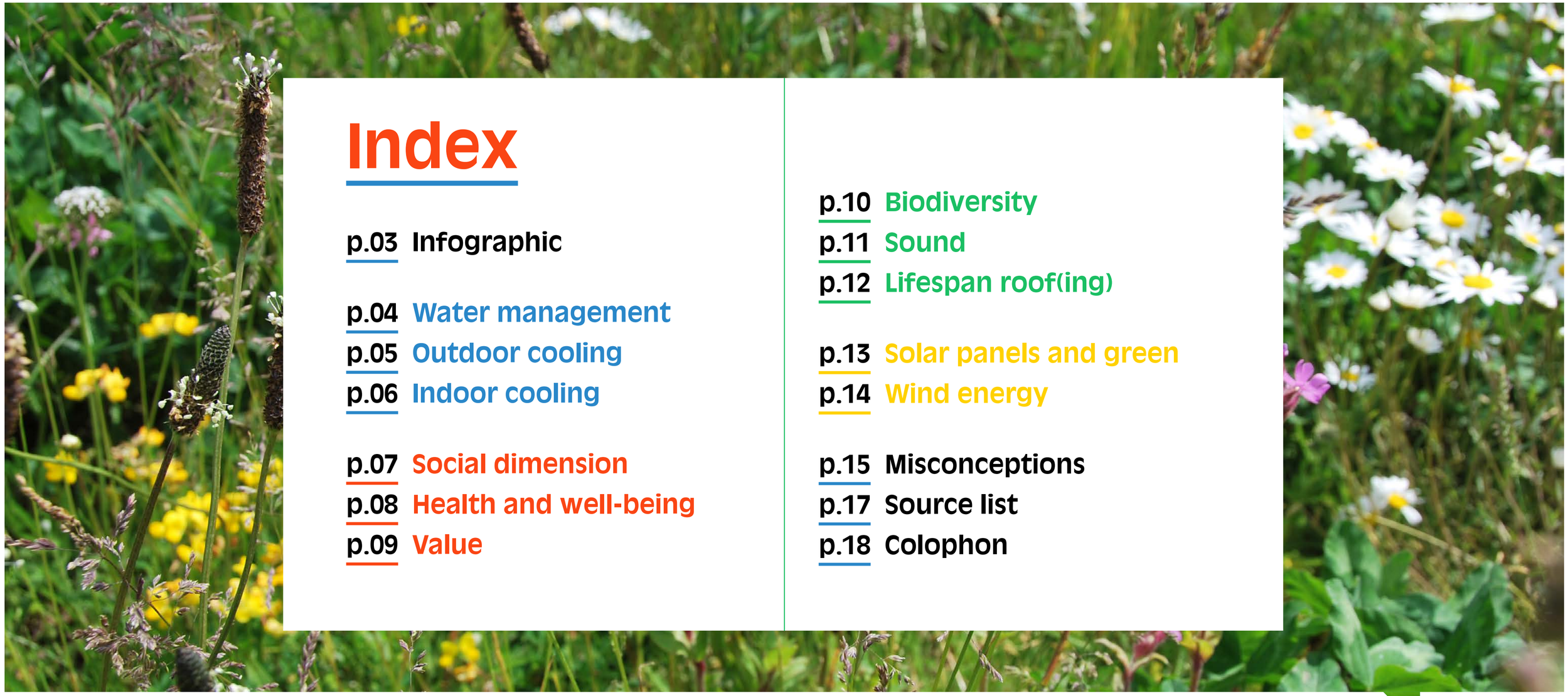
The Netherlands is a small and densely populated country. There is too little space to accommodate all the transitions society faces. We cannot afford to leave our roof landscape lay fallow. Rooftops as extra space – for the partners of the National Roof Plan, this phrase speaks for itself.

Energy production, water collection, more nature or extra social space – all this and more can take place on rooftops. However, this requires enabling laws, stimulating regulations and good funding opportunities. The partners of the National Roof Plan are working on these basic conditions to build more multifunctional roofs across the country. Qualitative information is essential for this.

For this reason, we present this document that compiles the facts and figures on multifunctional roofs and refutes common myths and misconceptions.

NATIONAAL DAKENPLAN

Index >



Index

NATIONAAL DAKENPLAN

Multifunctional roofs

NATIONAAL DAKENPLAN

Water management

* **More evaporation**
* **Less rainwater runoff from rooftop into sewer system, surface water or topsoil.**
* **Reduced sewer overflow (less contaminated water overflowing into surface water)**
* **Lower domestic use of drinking water**

More evaporation

With a blue roof (e.g. in combination with a green or red roof), the roof surface retains water, which either evaporates (evapotranspiration) or is discharged with delay to infiltration or drainage systems. This reduces the peak load of a short but intense cloudbursts both at street level and for municipal sewer systems. It contributes to making the built environment more climate-proof. The sponge effect of green roofs on their own is not reliable for water management. Of course, every drop counts. As their numbers increase, green roofs will make a greater contribution to urban water management.

More specifically, a high percentage of green roofs in a neighbourhood will result in:

65% more evapotranspiration
An increase in evapotranspiration: from 23% of all precipitation in a neighborhood with no green roofs, to 38% of all precipitation in a neighborhood with 100% highly effective blue-green roofs (i.e. roofs that can buffer 70 mm rainwater, limiting runoff)

17% less run-off to sewer system
Less runoff going to wastewater treatment: with an average mixed sewer system and no blue-green roofs, 72% of all precipitation goes into wastewater treatment. This is reduced to 60% in a neighbourhood with 100% blue-green roofs.

40% less sewer overflow into surface water
A decrease in sewer overflow volume: from 5.5% of all rainfall overflowing in an average mixed sewer system with no green-blue roofs to 2.2% overflowing when there are 100% highly effective blue-green roofs.

Computer controlled water storage

Automated adaptable roof drainage, based on weather predictions, offers additional benefits for water management by optimizing the timing of drainage and retention for cloudbursts and dry spells.

Conservation of precious drinking water

By using rainwater for watering plants (on roofs and facades) and flushing toilets (grey water systems), the use of valuable drinking water can be reduced.

NATIONAAL DAKENPLAN

Outdoor cooling

* **Greater reflection of sunlight**
* **Lower roof temperature in summer**
* **Reduction in urban heat stress**

Up to six times more sunlight reflected

Sunlight reflection is up to six times higher on green roofs than on regular dark roofing. Bitumen reflects 5% of incoming sunlight, while short grass reflects 15% and long grass 30%.

35°C instead of 70 - 90°C

These values only apply when the green roof has sufficient water content, meaning when evaporation can take place. The higher the water availability, the longer the cooling effect of the roof. No heat accumulation within the roof itself takes place when water is evaporating. Hence, the daytime temperature of the roof will warm up to the surrounding temperature.

NATIONAAL DAKENPLAN

Indoor cooling

* **Lower indoor temperature**

Indoor temperature up to 7 - 8°C lower

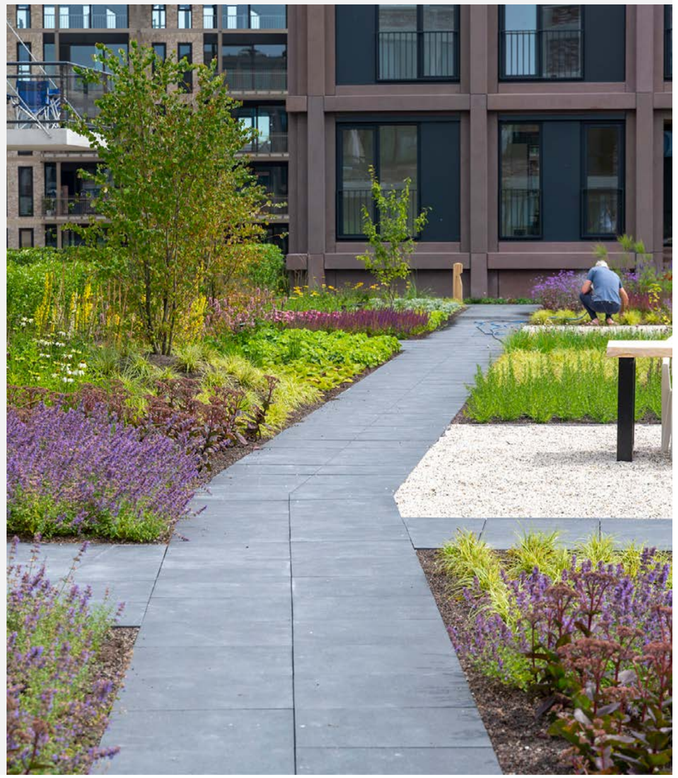
Lower surface temperatures of green roofs also reduce indoor temperatures. As a result, less energy is needed for cooling on hot days. Ongoing research appears to support that indoor temperatures under a green roof can be as much as 7 - 8°C lower than under a black roof. This is a greater temperature difference than the average cooling (5°C) that air conditioners generally provide.

70 - 90% less heat transfer from outside to inside

By adjusting the selection of plant species, the planting density and the amount of water storage on the roof, the temperature on (and just above) the roof can be influenced. If the indoor and outdoor temperature difference is smaller, the heat transfer to the inside of the building will also be lower. So, even if roofs have a similar insulation value, a green roof will provide more cooling. Studies done in places with climatic conditions similar to the Netherlands show that a green roof can reduce the average daily heat transfer into the building by 70 to 90% in summer.

Good roof insulation remains important

The insulation value of a green roof is minimal in winter. A green roof therefore cannot replace the need for good roof insulation.



NATIONAAL DAKENPLAN

Social dimension

*** More social cohesion**

More social cohesion

With a social roof, also known as a ‘red’ roof, the roof surface becomes an extension of the building. On red roofs, people come together to meet and recreate. They are (partially) paved roofs meant for social activities: children’s playgrounds, terraces, bars and sports centres high above street level. In increasingly crowded cities, these social roofs make extra efficient use of available space and often strengthen social cohesion too.

NATIONAAL DAKENPLAN

Health and well-being

* **Supports stress relief and stimulates immune system**
* **Improves mental health**
* **Supports recovery after a hospital procedure**
* **Improves focus and work productivity**

Relaxtion and stress relief
Our bodies and brains are more attuned to a green, natural environment than to our modern urban context. Natural surroundings provide relaxation and reduce stress and pain.

Improved focus
40 seconds of looking at a green roof improves the ability to concentrate.

Less paind and faster recovery
A US study, for example, found that patients with a view of trees needed up to 30% less heavy painkillers and the length of their hospital stay after surgery decreased by almost 10% (compared to a view of a brick wall). Since then, there have been many more studies confirming this correlation.

NATIONAAL DAKENPLAN

Value

* **Maintains and enhances value**

* **Positive influence on building label score**

Residents happier in their home

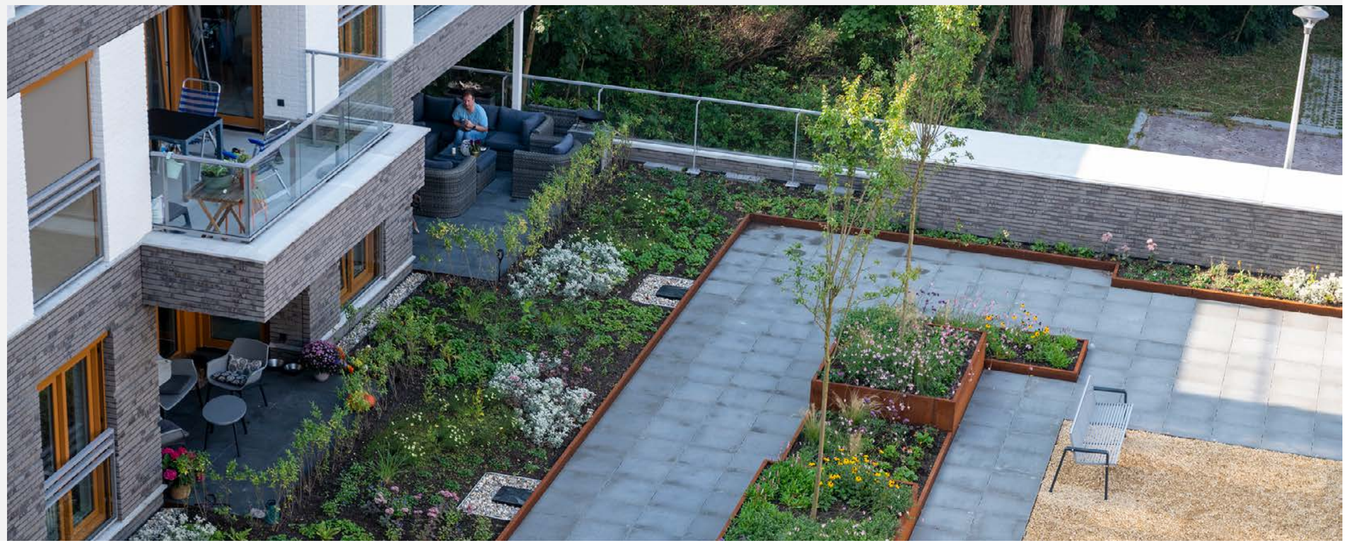
The joy residents ascribe to their living situation increases when homes have a view of, or are in close proximity to, green and/or blue surroundings. For direct enjoyment, the visibility of trees and/or plants from the home is a prerequisite.

Value increases

More usable space in the form of a roof (vegetable) garden, roof terrace, sports roof or parking roof increases the value of the building, but also increases the sense of well-being of its residents.

Higher score on building labels

Sustainable roofs score points in various building label systems that grade sustainability, like BREEAM, LEED, WELL, HOE (French), DGNB (German).



NATIONAAL DAKENPLAN

Biodiversity

*** More biodiversity**

More living space for people, plants and animals

Green roofs provide habitat for plants, animals and people. Green roofs help increase the diversity of plant and animal species, meaning more flowers, butterflies, birds and other creatures.

More species diversity

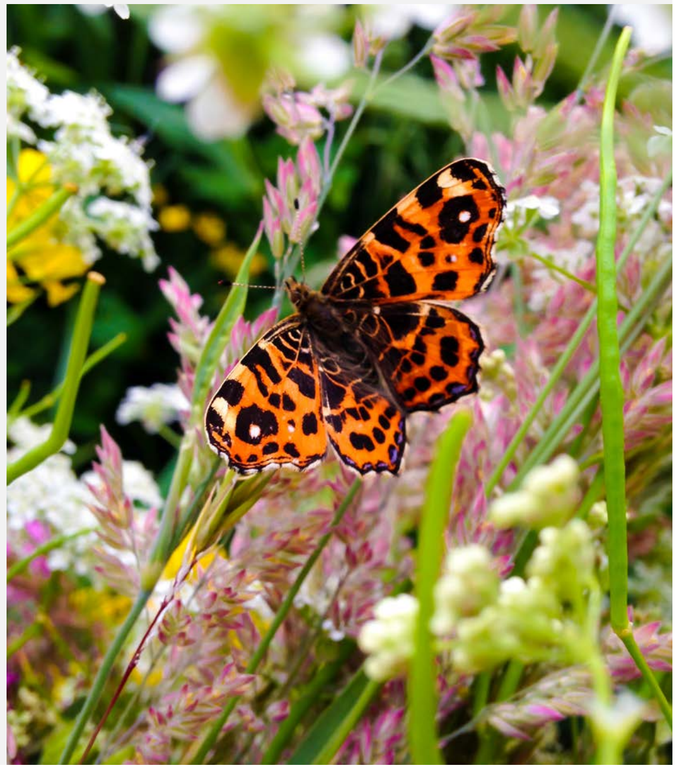
A relatively large number of plant species can live on green roofs. By creating different zones that are more sunny or more shady, for instance with solar panels, the diversity of species can be increased even further. Plantingnative grasses and herbs can also contribute to higher biodiversity.

Shelter and nesting places

Besides being a food source for insects, butterflies and birds, green roofs also provide nesting places for ground-breeding birds, while solar panels can provide shelter for animals.

Vital soil life

Healthy soil life in a nutritious topsoil of organic matter also contributes to biodiversity. Soil biodiversity is essential for all biodiversity.



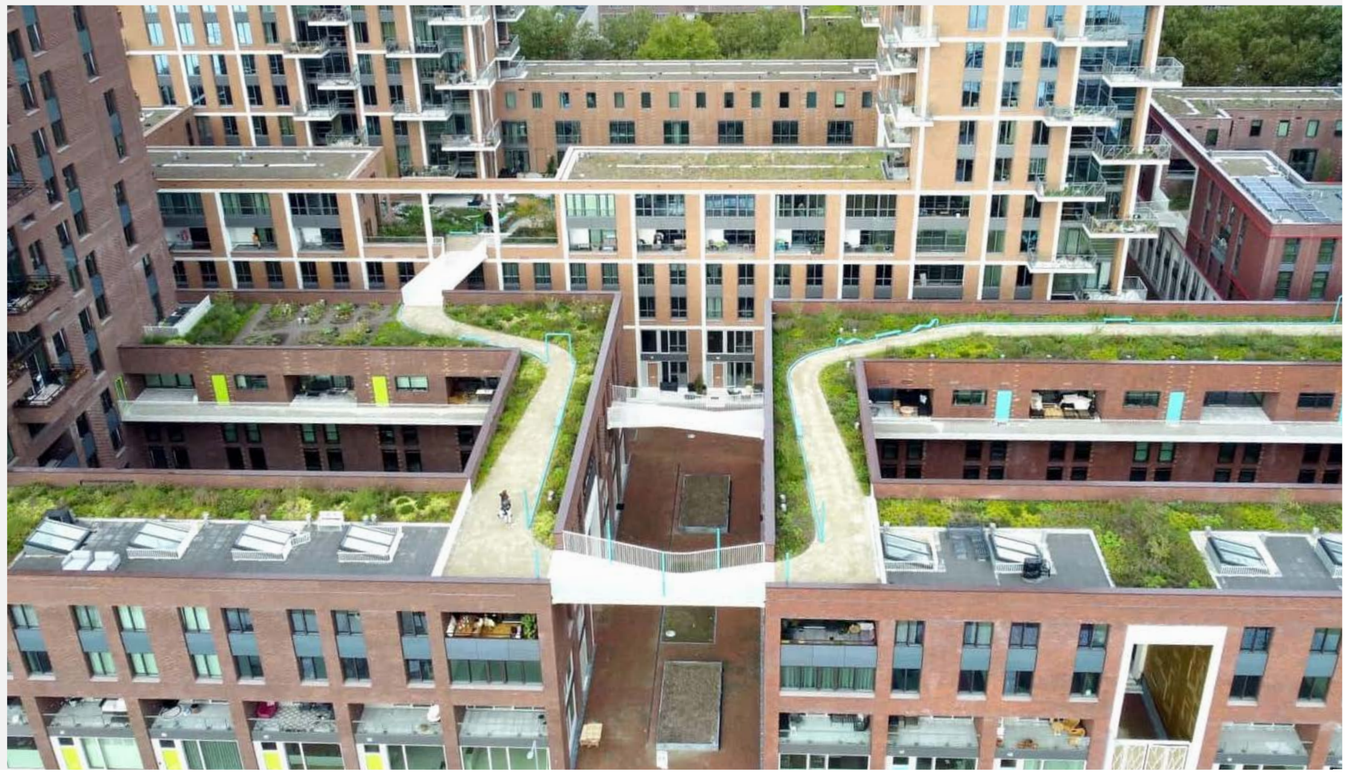
NATIONAAL DAKENPLAN

Sound

*** Absorbs sound**

Up to 3dB noise reduction

Noise reduction depends on the vegetation and the substrate – its type, thickness and moisture content. Therefore, the noise reduction is not constant and may vary. Green roofs can reduce noise reflection by up to 3dB.



NATIONAAL DAKENPLAN

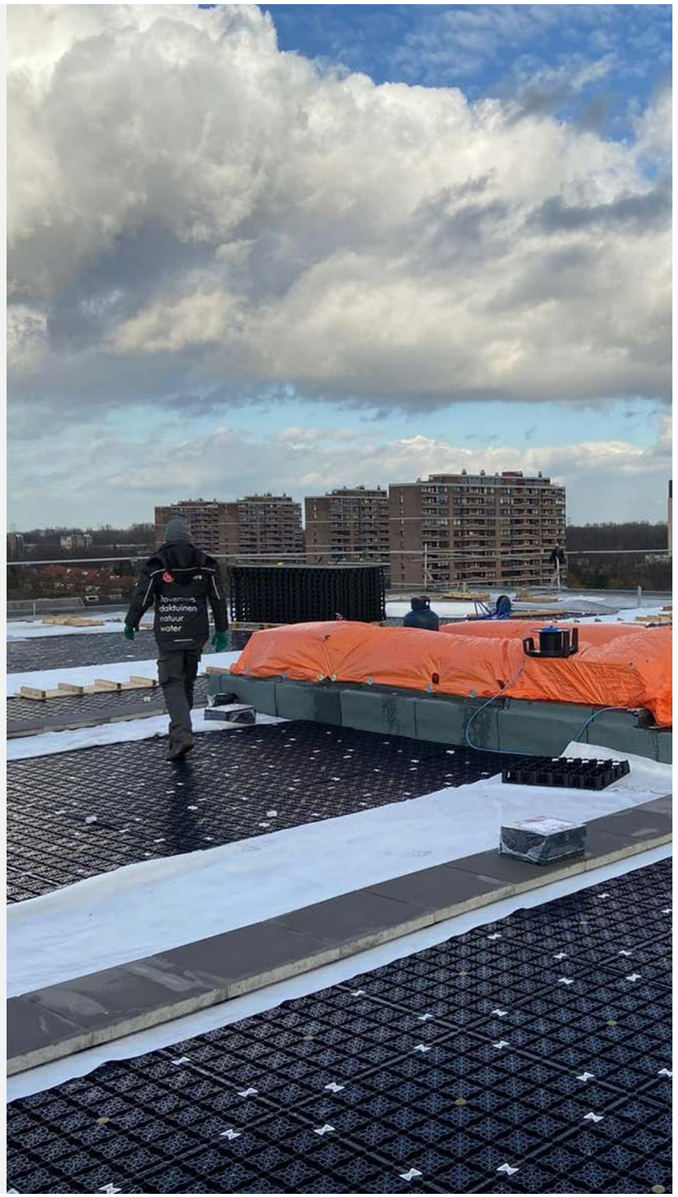
Lifespan roof(ing)

*** Doubles lifespan of roofing materials**

Lifespan of roofing is doubled

Empirical data increasingly shows the lifespan of the underlying roofing material can be doubled (at least) by adding a green roof. The extra layer of substrate and plants shields from the harmful effects of UV radiation and reduce temperature fluctuations to occur less or not at all. Proper maintenance of the green roof is a must, and it might also be necessary to upgrade of the edges of the roof.

Good quality bituminous roofing has a proven lifespan of about 35 (to 40) years. This lifespan is similar to other roofing materials. Roofing lasts up to twice as long by adding a green roof, around 70 years in total. Of course, proper maintenance is a must. This makes the lifespan of green roofs comparable to that of roof tiles. This means that a green roof meets the 50-year requirement for the standardized



NATIONAAL DAKENPLAN

Solar panels and green

* **Higher solar panel efficiency**
* **Extra CO_2 reduction**
* **More biodiversity**

Between 5 - 16% higher energy production from solar panels cooled by a green roof

Solar panels cooled by surrounding plants produce 16% more than solar panels on a black roof. This is because a green roof stays a lot cooler during the day than a bare roof. This prevents solar panels from overheating, which reduces their efficiency to produce power (or heat). The study showed that the green roof was as much as 20°C cooler than the bare roof at certain times. The green roof has to continue underneath the solar panels though. The lowest point of the solar panels must be 25-30 cm above the vegetation to allow the hot air to dissipate.

Optimal conditions solar power

The stated power of a photovoltaic panel is based on its performance with a surrounding temperature of 25°C (Standard Testing Conditions). The energy it delivers becomes less as the temperature rises (around 0,35% less for every degree of temperature rise) and it delivers more enery as the temperature decreases (around 0,35% more for every degree of temperature decrease). Solar panels work best when the sun is strong and it is cold outside.

Green/Blue layer as counterweight

The vegetation layer can act as a counter-weight for mounting solar panels. With blue roofs, the solar panels can be mounted directly onto the crate system of the water retention layer.

More biodiversity

Biodiversity is increased by the combination of sun-loving and shade-loving plants.

NATIONAAL DAKENPLAN

Wind energy

*** CO_2 reduction**

Possible CO_2 reduction of up to 4 ton per year

Rooftop wind turbines can be used to generate energy. The yield is directly linked to reducing CO_2 emissions and depends on wind speed. For an average wind speed of 4 m/s, the CO_2 reduction is between 190 - 1178 kg/year, depending on the model of turbine being used. For an average wind speed of 6 m/s, the CO_2 reduction is between 1270 - 4300 kg/year, again depending on the model.

NATIONAAL DAKENPLAN

Misconceptions

part 1

In the dynamic new market-place of multifunctional roofs, there are also myths going around about the effects and properties of sustainable roofs. Here, some of those myths and misconceptions are listed in order to clarify actual and alleged benefits of sustainable roofs.

Considerable constribution to carbon sequestration

Green roofs are said to make a substantial contribution to carbon sequestration, referring to the natural process by which plants and trees absorb CO_2 as they grow. However, this contribution of rooftop greenery is so small that we do not mention it as an explicit benefit. German research showed that it will take 48 years for an average green roof to absorb the amount of CO_2 that was emitted by producing and laying a green roof in the first place.

N.B. CO_2 uptake by plants depends on the species and planting density. It would be interesting to do more research into which plants contribute most in terms of carbon sequestration as well as nitrogen uptake.

The application of olivine, a type of mineral stone that can extract and store its own weight in CO_2 from the air, could contribute to CO_2 reduction if it was applied on a large scale.

Insulation effect in winter

It is said that a green roof insulates and keeps heat inside in winter. However, this insulating effect in winter is so limited that it is not listed as a value here. Green roofs do contribute to cooling indoor spaces in summer (as long as there is water on the roof to evaporate).

Absorbing air pollution

Vegetation on roofs is said to absorb particulate matter and reduce air pollution. Studies have shown that this effect is very minimal. Therefore, it is not a valid argument for building green roofs.

Enabling blue-green algae and bacteria

It is said that water retention on rooftops increases the risk of spreading blue-green algae and pathogenic bacteria (including legionella). On surfaces where temperatures above 25°C persist for more than 24 hours,

read more >

NATIONAAL DAKENPLAN

Misconceptions

part 2

these bacteria can form. On blue-green roofs, the vegetation layer ensures that the temperature does not reach or remain too high. The risk of spreading malaria via mosquito eggs in prolonged stagnant water is avoided by covering the water and ensuring adequate drainage capacity.

Greater risk of fire

It is said that sustainable roof use is a fire hazard. This is incorrect. According to the NTA 8292, extensive green roofs with a specific substrate composition of at least 40 mm, have been tested in accordance with the NEN 6063 and they complied with BRoof(t1). Roofs combing blue, green and yellow (solar), actually reduce fire risk due to the water availability in the water retention layer of the roof. During dry spells, the sedum plants, together with the substrate and drainage layers, actually contain relatively large amounts of moisture. These roofs therefore comply with national building regulations and do not pose a fire hazard. If a fire would occur due to malfunctioning solar panels, the green roof acts as a fire retardant.

Greater risk of frost damage

A (blue-)green roof is said to increase the risk of freezing and consequent damage. However, a year-long study of hourly temperature measurements showed that a green roof did not go below 0°C. This same study did find that after night frost the indoor space takes longer to warm up under a green roof. It depends on the insulation value of the roof, and the effect is limited when considering the whole year.

Risk of roof leaking

It is said that plant roots pose a risk for creating leaks in the roof. However, the installation of root-resistant roofing materials or an additional root-resistant membrane eliminates the risk of leaks caused by root growth.

Solar panels up to the edge

In practice, solar panels are still installed right up to the redge of the roof to maximize the area for energy production. Laws and regulations do not allow this: there should always be a 2 metre zone along roof edges where maintenance can be safely carried out.

NATIONAAL DAKENPLAN

Source list

Water management

Busker, T., de Moel, H., Haer, T., Schmeits, M., van den Hurk, B., Myers, K., Cirkel, D.G., Aerts, J. (2022). Blue-green roofs with forecast-based operation to reduce the impact of weather extremes. Journal of Environmental Managements, vol 301 (113750).

Cristiano, E., Annis, A., Apollonio, C., Pumo, D., Urru, S., Viola, F., & Deidda, R. (2022). Multilayer blue-green roofs as nature-based solutions for water and thermal insulation. Hydrology Research, p. 1129-1149.

Groene Daken nader beschouwd (2015, RIONED, STOWA)

Hamel, A. (2021). Towards climate resilient green-blue roofs. Delft.

RESILIO. (2022). RESILIO Final report: A roof journey. Amsterdam.

Biodiversity

Groene Daken nader beschouwd (2015, RIONED, STOWA)

Heerewaarden, W. van; Zeegers, T.; Kuik, A.J. van (2019). Handreiking natuurdaken, Green Deal Groene Daken, Wageningen University and Research (m.n. p22 t/m p26).

Köhler, M., Wiartalla, W., Feige, R. (2007). Interaction between PV systems and extensive green roofs. Fifth Annual Greening Rooftops for Sustainable Communities Conference, Minneapolis.

Star, A. (2009). Het upgraden van het riool tot een groendak. Hogeschool Van Hall Larenstein.

Outdoor cooling

Groene Daken nader beschouwd (2015, RIONED, STOWA)

Spijker, J.H.; Ravesloot, M.B.M.; Hiemstra, J.A.; Vries, S. de (2022). Groen en zorg, de meerwaarde van groen in de stedelijke omgeving. Wageningen University and Research.

Indoor cooling

Jaffal, I., S.E. Ouldboukhitine & R. Belarbi (2012). A comprehensive study of the impact of green roofs on building energy performance. Renewable Energy vol. 43: p. 157-164.

Groene Daken nader beschouwd (2015, RIONED, STOWA)

Solar panels and green

Irga,P.; Fleck, R.; Wooster, E.; Torpy, F.; Alameddine, H.; Sharman, L (2021). Green Roof & Solar Array – Comparative Research Project Final Report July. University of Technology Sydney.

Smart Sustainable Districts - Deepdive Utrecht. (2016). Synergie groen dak - Zon-PV.

Wind energy

Arcadis, Provincie Utrecht (2010). Boven onze hoofden een groot potentieel Milieu- en economische effecten van duurzame daken.

Social dimension

Gemeente Rotterdam (2019). Naar een Rotterdams Dakland-schap

Stuiver, M.; Spijker, J.; vries, de S.; Snep, R (2018). Zeven redenen om te investeren in een groene stad. Wageningen University and Research.

Health and well-being

Lee, K.; Williams,K.; Sargent, L.; Williams, N.; Johnson, K (2015). 40-second green roof views sustain attention: The role of micro-breaks in attention restoration, Journal of Environmental Psychology, vol. 42: p. 182-189.

Nielsen T.; Hansen, K (2007). Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators. Health Place. Vol.13(4), p. 839-50.

Ulrich,R.S. (1984) View through a window may influence recovery from surgery. Science. Vol. 224(4647).

World Health Organization (2016). Urban green spaces and health.

Sound

Groene Daken nader beschouwd (2015, RIONED, STOWA)

Lifespan roof(ing)

Groene Daken nader beschouwd (2015, RIONED, STOWA)

Porsche, U.; Kohler, M. (2003). Life cycle costs of green roofs - A Comparison of Germany, USA, and Brazil. University of Applied Sciences Neubrandenburg.

Value

Veraart, J.; Boer, de R.; Bruin, de K (2021). Gebruik kennis over economische waarden van natuur en ecosysteemdiensten bij besluitvorming en ontwerp van natuurherstel- en ontwikkelingsprojecten. Wageningen University and Research.

NATIONAAL DAKENPLAN

Colophon

Published June 2023

Aart Veerman, Van der Tol Groep b.v. ; Albert Jan Kerssen, ID Verde; Barbara Wolfs, Zoontjens; Dick Oosthoek, Groenkeur.nl; Henk Vlijm, Optigruen; Ieke Benschop, NMU; Jan Cromwijk, ISSO; Joost Jacobi, Wavin; Kasper Spaan, Waternet; Kees Broks, STOWA; Michiel van de Bunt, Zinco.nl; Nick Post, ISSO; Oscar Kunst, RIONED; Roos de Jager, NDP; Stef Janssen, TU Delft / Ebben

The National Roof Plan is a public-private network organisation in which companies, governments, knowledge institutes and civil society organisations work together to ensure the basic conditions necessary to build more multifunctional roofs. Rooftops as extra space: for the partners of the National Roof Plan, this phrase speaks for itself. Energy production, water collection, more nature or extra social space – all this and more can take place on rooftops.

In this publication, you will learn about the benefits of different types of roofs and the misconceptions surrounding sustainable roofs. The partners of the National Roof Plan strongly encourage combining functions on your rooftop, which will result in multifunctional synergies and benefits. For example, solar panels by vegetation underneath deliver more energy, while water storage can be easily added underneath many other functions, load-bearing capacity of the roof permitting, like a roof garden or rooftop bar.

www.dakenplan.nl

INDEX

NATIONAAL DAKENPLAN