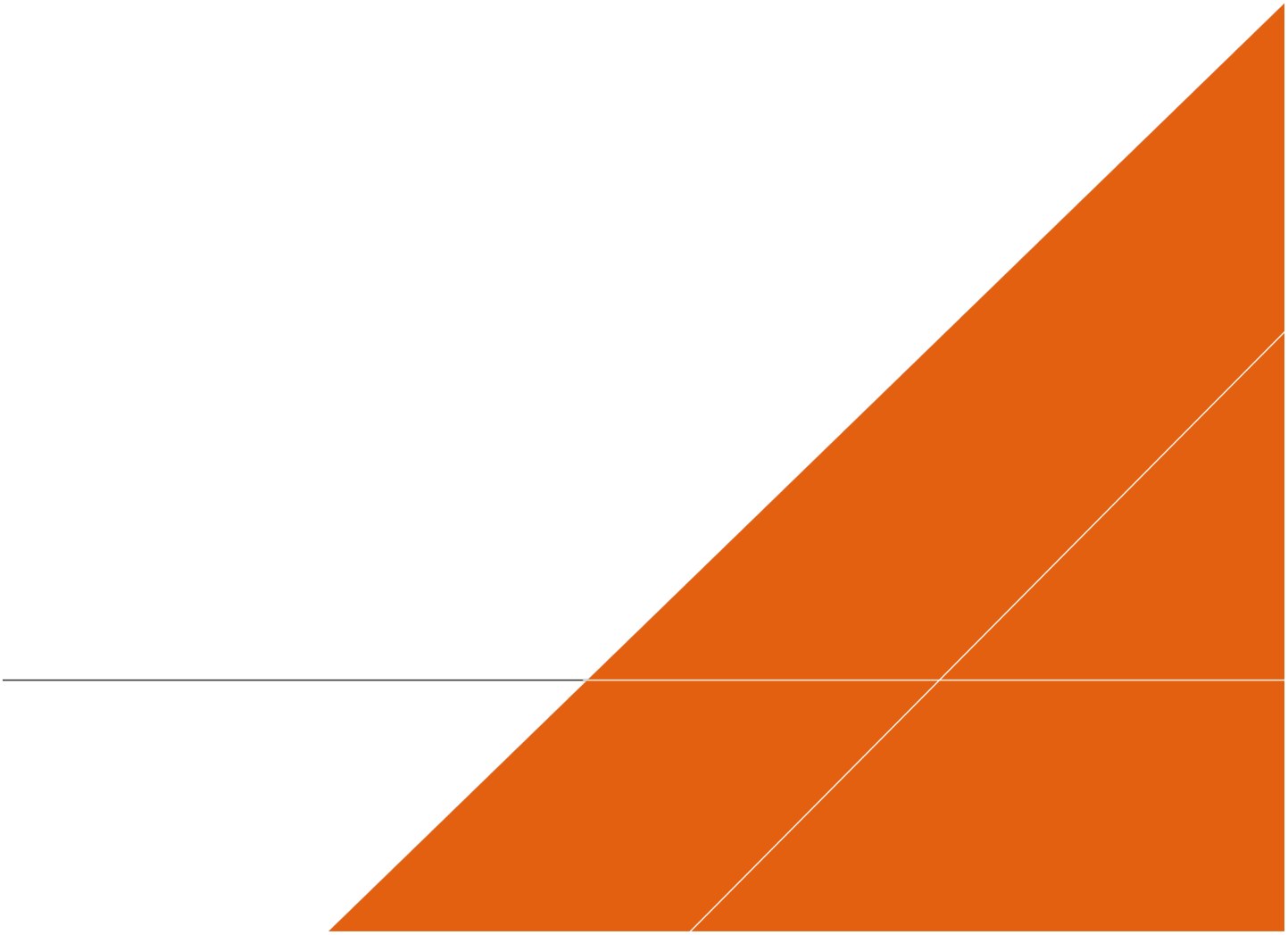
LIFE @ URBAN ROOFS 2.0

Background Report Key Figures

21 MAY 2021



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1 INTRODUCTION

1.1 Problem statement

In the urban environment, there is little room at ground level to tackle climate and water challenges. At the same time, a large amount of roof area in the city remains unused. Roofs offer all kinds of opportunities for use and can have an important contribution to the living environment and quality of life in the city. This can be used by the construction of multifunctional roofs, such as a combination of a roof with a green function (vegetation) and a yellow function (solar panels).

People want to experience the benefits of multifunctional roofs (through usage, energy, water retention, etc.), but it is difficult to find parties willing to pay for these investments. This has several causes. The main reason is that the benefits of multifunctional roofs are not always clear. Not all benefits can be directly valued in Euro's and are not immediately visible to all users (or more importantly, to the investor). The tool LIFE @ Urban Roofs offers a solution to this matter. The social costs and benefits, in addition to the financial costs and benefits, are made visible by means of the tool, version 2.0, that has been developed for the European Union (EU) program LIFE @Urban Roofs.

1.2 The LIFE program

Within the framework of the EU program LIFE, the municipality of Rotterdam has started the LIFE @Urban Roofs project in collaboration with several Rotterdam partners. The aim of the project is to develop methods to simplify investments in multifunctional roofs in the private and (semi) public sector. In addition, the EU program LIFE @Urban Roofs aims to share knowledge between cities and / or countries with the same type of issues.

1.3 Reading guide

The purpose of this background report is to elaborate on the effects and corresponding key figures that were used in the tool LIFE @ Urban Roofs version 2.0. In the following chapters you will read about:

- General assumptions (Chapter 2)
- Explanation of the financial business case (Chapter 3)
- Explanation of the social cost-benefit analysis, including a description of the valuing method of effects that are of relevance (Chapter 4)
- Key figures and assumptions that are used (Chapter 5).

Important note: The LIFE @ Urban Roofs calculation tool has been developed in light of the context of the LIFE program. The methodology and key figures described in this background report only apply to this scope. For additional questions or application elsewhere, please contact Arcadis via jolijn.posma@arcadis.com.

2 USING THE TOOL

2.1 The user

The tool LIFE @ Urban Roofs provides insights into the financial business case and the social costs and benefits of a multifunctional rooftop. For more information about multifunctional rooftops, follow this link: https://duurzaam010.nl/product/daken.

Since the publication of the 1.0 version of the tool, several organizations have used it. The 2.0 version of LIFE @ Urban Roofs is an update, but also an improvement of the tool. Through a user session the wishes and suggestions for the 2.0 version were retrieved. The 2.0 version of the tool LIFE @Urban Roofs has been developed mainly to update and improve the usability of the tool in comparison to the 1.0 version. The goals of the LIFE program have been leading in this.

The 2.0 tool can mainly be used as an incentive instrument but can also be used to inspire and inform about the application of multifunctional roofs. The purpose of the tool is to get a good first impression of what is possible when using multifunctional roofs with limited input. The tool can therefore be seen as a QuickScan and first step towards a financial business case and social cost-benefit analysis (SCBA).

The tool is accessible to anyone interested in multifunctional roofs and who wants to make a first step in discovering their application. For the use of for municipalities, individuals, and enthusiasts alike. In the tool, default values are applied as much as possible. These values can be adapted to any specific case if desired.

2.2 Method

The tool consists of an Excel file with five separate sheets:

- Introduction sheet
- 1. Current situation
- 2. New rooftop
- 3. Results
- Next steps

The user will be guided through the tool step by step. It is constructed in such a way, that it would take the user about 15 minutes to fill in. Standard prices and -values have been entered where possible to assist the user. These values can be adapted by the user, if required. The user will fill in every yellow field or uses the standard values.

2.3 Types of multifunctional rooftops

The tool uses seven different colors to indicate the type of roof (Table 1: Description and effects of rooftop types included in LIFE @Urban RoofsTable 1).

Table 1: Description and effects of rooftop types included in LIFE @Urban Roofs

Rooftop type	Description and effects
Green roofs	Green roofs provide a green environment and are useful in cases of extreme dry, hot, and wet weather. The positive effects of a green roof are an increase in biodiversity, avoided healthcare costs, prevented loss of work, water retention and an increase in property value.
Blue roofs	Blue roofs collect and store water. They play an important role with very wet or dry weather. The positive effects of a blue roof are water retention and possible re-use of the collected water.
Yellow roofs	Yellow roofs generate renewable energy from the sun or the wind. The positive effects of this are the energy yield for the owner, a reduction in CO_2 emission in the generation of electricity and an improved air quality due to a reduction of pollutants generated with the generation of electricity.
Red roofs	Red roofs have a social function. People can meet each other on this type of roof and there are exploitation possibilities on a red roof.

Orange roofs	Orange roofs are used for transport and mobility.
Purple roofs	Purple roofs consist of living space.
Grey roofs	Grey roofs are for technical installations.

3 EXPLANATION OF THE FINANCIAL BUSINESS CASE

3.1 Starting points

In the financial business case, the costs (investment costs and maintenance costs) are compared with the financial benefits (e.g., energy yield or exploitation yield). This is done by determining the Net Present Value (NPV) of the project.

The NPV is a measure to display the current value of an amount for a given base year. The NPV considers the time value of money and the risks associated with an investment. To determine the NPV, the present value of future expenditure (total investment costs and management and maintenance costs) is deducted from the cash values of all future receipts (income). Future costs and benefits are discounted to the base year so that they become comparable.

The period of analysis can be set variably in the tool, varying from 10 to 60 years. The standard value is set to 40 years

Net present value

It is not possible to compare costs and benefits that occur in different periods. Investments are made when the project is implemented, while benefits occur later. Moreover, these effects could occur more often.

Cash values are used in the SCBA and the financial business case to compare all effects. Using a discount rate, the future values of costs and effects are recalculated back to today (price level 2020). Because of the time value of money, one Euro now is worth more than one Euro later in time. In addition, there are risks that the benefits will be lower in the future. These risks are also included in the discount rate.

In the financial business case, the discount rate that is set by the case holders will be used. A real discount rate of 2.25% is used in the SCBA, as prescribed by the Dutch national government. For CO_2 prices, a discount rate of 2.9% is used.

If the present value of the costs is deducted from the present value of the benefits, the balance referred to as NPV remains.

3.2 Costs and benefits

3.2.1 Costs

It is assumed that all costs are additional costs compared to the reference situation (i.e., regular maintenance). The costs in the financial business case consist of investment costs and maintenance costs. Additionally, subsidies in the financial business case are included as benefits. It is assumed that all subsidies are received in year 1.

3.2.2 Benefits

The benefits of the financial business case that are most important, relate to yellow, red, and blue roofs. Yellow roofs are designed for energy generation (equipped with solar panels and / or wind turbines). The energy yields generated by the roof are expressed in Euros and are included in the benefits. Red roofs have a social function. For instance, red roofs can consist of a bar or restaurant. In that case, the exploitation yields are included in the benefits. Thirdly, water retention on the roof offers opportunities for water re-use which could lead to costs for drinking water that are avoided.

4 EXPLANATION OF THE SOCIAL COST-BENEFIT ANALYSIS

4.1 Starting points

To determine the social costs and benefits, the General Guidance for Social Cost-Benefit Analysis (General SCBA Guidance) is followed as much as possible. This guidance describes step-by-step the approach of a SCBA. The guidance is written by the Dutch Centraal Planbureau (CPB) and the Dutch Planbureau voor de Leefomgeving (PBL). Please note, the tool LIFE @ Urban Roofs concerns a QuickScan. This means that not every formal step of an SCBA has been dealt with, see the text box below.

For the determination of the NPV, the same basic principles apply as described in the financial business case (see Chapter 2.1).

General Guide to SCBA

Strictly speaking, different steps must be taken - in accordance with the aforementioned General Guidelines - for the implementation of an SCBA, including a problem analysis and the development of several variants that could solve the problem. For example, the municipality of Rotterdam could also reduce CO_2 in a different way than by solar energy on roofs, for example by using extra energy-efficient transport.

However, this study focused on the social costs and benefits of multifunctional roofs because an analysis of alternative climate measures was not within this study's scope. In addition, multifunctional roofs may contribute to addressing more issues than just the climate problem (e.g., biodiversity, water retention, heat stress etc.), making it difficult to develop alternatives that contribute to a solution for all these issues.

4.2 Determination and valuation of relevant effects

In determining the relevant effects in the SCBA, a distinction has been made between effects that primarily occur to owners / users of objects (private) and the social effects (public). The private and public effects are both reflected in the SCBA. Table 2 presents the effects included in the SCBA and the method of valuation. The following sources have been consulted (see also the extended table with key figures in Chapter 4 and the Literature List in Chapter 5):

- General Guide to SCBA and the various SCBA instruments ("MKBA werkwijzers"), such as Nature, Environment and Social Domain
- Handboek Milieuprijzen (Environmental prices manual);
- Valuation characteristics from among others TEEB city, WaterSchadeSchatter, RWS economy.
- Similar SCBAs on green roofs.
- KNMI'14 climate scenarios.
- Other sources (see literature list in Chapter 6)

Table 2: Costs and benefits that multifunctional roofs can generate

Effect	Description	Valuation method
Costs		
Investment costs	*Additional* costs compared to the reference situation. In € per m² for each roof "color".	€
Maintenance costs	*Additional* costs € per m² of roof compared to the reference situation.	€ per year
(Social) benefits		
Energy yields	Energy generated	kWh per year
	Energy yields: replaced usage and energy send back into the public network / the grid. It is assumed that the energy generated is consumed for own consumption. If there is a surplus, this is returned to the grid. The generated electricity is valued at € 0.22 per kWh.	€ per year
	The energy revenues are made visible by expressing it in how many households are supplied with electricity per year.	Qualitative
Exploitation yields red roof	*Possibility of exploiting*: the effects of the multifunctional roof are made clear by indicating the yields of possible exploitation. This is expressed quantitatively	€
Property value	In literature, a range of 1.4-21% increase in property value can be seen because of the implementation of green roofs. The following default values are included: • 1.4% increase for green roofs smaller than 500 m² • 2.5% increase for green roofs smaller than 1000 m² • 5% increase for green roofs smaller than 2000 m² • 7.5% increase for green roofs smaller than 3000 m² • 10% increase for green roofs smaller than 4000 m² • 12.5% increase for green roofs smaller than 5000 m² • 15% increase for green roofs smaller than 6000 m² • 17.5% increase for green roofs smaller than 7000 m² • 20% increase for green roofs smaller than 8000 m² The property value increase reflects underlying effects such as: aesthetic appreciation, noise cancelling, productivity, and comfort. It is assumed that property value increase occurs once, in year 1.	€
Reputation and business climate	Effects on the reputation and business climate are approached from the following indicators: • *Reputation of the owner:* does the project contribute to a green / innovative profile of the owner of the building? This effect is described qualitatively. • *Business location climate of the district and city:* does the project contribute to an improved business climate for residents and businesses? This effect is described qualitatively.	Qualitative
Water retention	In the case of water retention, the physical criterion is the amount of extra m³ water retention by the project.	€

	This is based on shadow costs / avoided costs of an alternative retention facility (€ 500 per m3). The amount of water retention on a blue roof can be set manually. We assume that a green roof stores 10 mm of water per m^2.	
	Additionally, the stored water is expressed in the number of filled rain barrels.	Qualitative
Water re-use	The collected water can be re-used for own purposes (for example irrigation of the green roof). It is assumed that this avoids costs of €0.70 per m^3.	€
Water quality	Water storage on a multifunctional roof can lead to a reduction in the amount of m^3 of rainwater that reaches the water treatment system via the sewer system. Theoretically, this can result in a reduction in the energy and operating costs of water purification. However, the effect of a green roof is marginal and is therefore not included in the SCBA. The same reduction in the amount of m^3 of rainwater reaching the sewer can in principle locally reduce the number of overflows of sewage water on the surface water. This benefits the quality of the surface water. This effect is qualitatively described in the report.	Qualitative
CO_2 emissions	The energy generation on rooftops can lead to a reduction of CO_2 emissions. This is valued using the Handboek Milieuprijzen. The capture of CO_2 from green roofs is limited. The Handboek Milieuprijzen contains environmental prices for over 2000 environmentally hazardous substances. The use of these prices is recommended by the national government (Rijksoverheid). The benefits of avoided emissions (CO_2 and other emissions: fine particulate matter, NO_x, SO_2) are included in the tool. See the effect of *air quality*.	€
Air quality	The effects of avoided emissions from fossil plants are valued using the Handboek Milieuprijzen. This includes environmental prices for more than 2000 environmentally hazardous substances. The use of environmental prices is recommended by the Dutch Ministry of I&W. We will determine the benefits for the saved emissions of CO_2 and air polluting emissions that are avoided (fine particulate matter, NO_x, SO_2).	€
Capture of fine particulate matter	Green roofs capture limited amounts of fine particulate matter. This effect has been valued in Euro's.	€
Heat stress	The effects on heat stress are determined by: • Albedo effect: different reflection of sunlight (assuming that there is a black roof in the reference situation). • Increasing insulation. • More evaporation; cooling effect of the environment (blue roof). In other words, heat stress is visible in two ways: the effect on energy in the building (albedo and insulation) and the effect on energy outside the building (cooling environment by evaporation). The effect on energy costs in the building is almost zero. The effect on energy outside the building (cooling environment) runs via the health effect (see below, the remains are qualitatively described).	Qualitative

Health (physical and mental)	The health effect has been approached based on two underlying effects: • *Avoided health care costs:* 0.835 fewer patients per 1000 inhabitants at 1% more green within a radius of 1 km around the building; € 917 per patient (TEEB city). For roofs it is assumed that 0.835 / 5 = 0.167 fewer patients within a radius of 200 meters. It is assumed that only residents of the building benefit from it. • *Prevented labor loss*: € 6,679 per patient (TEEB city). • The health effect includes both physical and mental health effects. The effect of heat stress is also included.	€
Social cohesion	With this effect we describe whether the project leads to additional opportunities for personal contact (at ground level or on the roof) and less crime due to greening	Qualitative
Biodiversity contribution (according to the *natuurpuntensysteem*, the nature points system)	Based on the type of green roof and the area of greenery of the constructed roof, the number of nature points were determined using a nature points system. Additional information can be found in section 4.3	Qualitative
Contribution to credit BREAAM	Based on the BREEAM method, it is examined to what extent the construction of the multifunctional roof contributes to the realization of sustainable buildings with a minimal environmental impact. Consider, for example, improving the water quality or promoting social cohesion in an area. This can be made qualitatively visible based on the total number of BREEAM points. Additional information can be found in section 4.4.	Qualitative
Housing	Purple roofs lead to additional m² of living space. This is qualitatively described.	Qualitative
Mobility	Orange roofs contribute to an improved mobility. This effect is qualitatively described.	Qualitative

4.3 Nature points

The nature point system (*natuurpuntensysteem)* determines how many points can be obtained with the construction of a multifunctional roof. A developer or architect can choose from a list of green roofs when creating his design. A different number of points has been awarded to different types of roofs. For example, the construction of a biodiverse roof is awarded with 3 points, the construction of a sedum roof yields 2 points, and the application of for example an insect stone provides 1 point. A selection of the Nature Points has been included in the tool (Table 3).

The nature points system is used by, among others, the municipality of The Hague and the Covenant Climate-proof Building South Holland (Bouw Adaptief). For a small project (500m² footprint) 2 points were requested on the facade and the roof. For a medium-sized project (<2000 m²) 4 points, and for a large project (> 2000 m²), 6 points.

Table 3: Natuurpunten (Nature Points)

	Natuurpunten
1	Green roof with sedum (>5-7cm)/30%
2	Green roof with sedum, grass, and herbs (>7-15cm)/30%
3	Green roof with (sedum), grass and herbs, dwarf shrubs and shrubs (15-30 cm)/30%
4	Green roof with (grass), herbs, dwarf shrubs and shrubs (30-50 cm)/30%
4	Green roof with herbs, dwarf shrubs, shrubs, and trees (>50 cm) /30%

4.4 BREEAM

The Building Research Establishment Environmental Assessment Method (BREAAM) is used in more than 80 countries worldwide. The method was originally developed by the Building Research Establishment (BRE). BREEAM-NL has been the certification method for a sustainable built environment since 2009. With this method, projects can be assessed for integral sustainability. BREEAM-NL has four quality marks.

With the BREEAM-NL Area quality mark, a complete area is assessed for sustainability. This can be a redevelopment of existing areas, but the certification of new area developments is also possible. The sustainability label addresses various current themes such as heat stress, climate adaptation and health by improving local air quality and social cohesion. This makes BREEAM-NL Area the measurement instrument for sustainable area development in the Netherlands. Multifunctional roofs can contribute to this measurement. A selection of credits from BREEAM has been included in this tool (Table 4).

Table 4: Applied BREEAM-points

SON 5	Encouraging administrative and/or financial participation of users in the area in order to increase their involvement with and responsibility for the area.
SON 6	Encouraging cooperation and financing arrangements between stakeholders to increase the feasibility of sustainability ambition in the area.
BRO 3	Boosting the local generation of renewable energy.
BRO 4	Reducing the use of drinking water in the area.
RO 7	Preserving and increasing biodiversity and its ecological value and function at local and regional level and sustainable conservation.
RO 8	Encouraging intensive use of space to minimise land use for buildings.
RO 11	Minimizing the flood risk in the area after development.
RO 12	Preventing damage to the built environment and vital and fragile functions due to extreme precipitation.
RO 13	Stimulating an optimal system for the use of people and transport needs (products) of an area and its environment with the lowest possible environmental impact.
DO 2	Promoting social cohesion in the area.
DO 3	Improving the quality of the environmental experience.
KLI 1	Stimulating a good thermal outdoor climate for users and preventing heat stress.
KLI 3	Optimizing local air quality.

5 APPLIED KEY FIGURES

The following table substantiates the assumptions and key figures used from the LIFE @ Urban Roofs version 2.0.

Category	Effect / assumption	Key figure	Unit	Source
General	Discount rate of costs and benefits (excluding CO_2 emission) (Default value, but can be adapted by the user)	2.25	%	Rijksoverheid 2021: https://www.rwseconomie.nl/discontovoet
General	Discount rate CO_2 emission	2.9	%	Rijksoverheid 2021: https://www.rwseconomie.nl/discontovoet
General	Default period of analysis (Adaptable by the user)	40	Year	-
General	Price level	2020	Year	Consumenten Prijs Index 2020, CBS
General	All costs and benefits are excluding VAT			
Additional investment costs of multifunctional roofs[1, 2]	Regular roof replacement costs	45	€ / m²	https://www.dakdekker-weetjes.nl
Additional investment costs of multifunctional roofs	Regular roof replacement period[2]. Additionally, it is assumed that the replacement period of regular roofs increases with the construction of a green roof with sedum. 60 years instead of 20 years (simultaneously with the green roof).	20	Year	https://www.dakdekker-weetjes.nl
Additional investment costs of multifunctional roofs	Blue roof investment costs	80	€ / m²	https://www.rainproof.nl/sites/default/files/poster_water_op_groene_daken_web.pdf
Additional investment costs of multifunctional roofs	Blue roof replacement period	30	Year	Assumption; expert judgement
Additional investment costs of multifunctional roofs	Yellow roof (solar panels) investment costs	470	€ / panel	https://www.zonneplan.nl/kenniscentrum https://www.zonnepanelen-weetjes.nl/prijzen-zonnepanelen/

[1] These are *additional* costs compared to the regular costs for the roof. In the cost-benefit analysis, we therefore assume *additional* costs compared to regular roof management. However, with multifunctional roofs, the replacement period for the regular roof is longer. This leads to a benefit. It is assumed that this benefit occurs at the time of the regular replacement term.
[2] This is a default value, and can be changed by the user of the tool.

Additional investment costs of multifunctional roofs	Yellow roof (solar panels) replacement period	25	Year	https://www.zonnepanelen-weetjes.nl/prijzen-zonnepanelen/
Additional investment costs of multifunctional roofs	Green roof (resp. sedum-, nature-, and garden roof) investment costs	50, 75, and 90	€ / m²	https://www.rainproof.nl/sites/default/files/poster_water_op_groene_daken_web.pdf
Additional investment costs of multifunctional roofs	Green roof with sedum: replacement period	60	Year	https://www.rainproof.nl/sites/default/files/poster_water_op_groene_daken_web.pdf
Additional investment costs of multifunctional roofs	Nature roof and garden: replacement period	30	Year	https://www.rainproof.nl/sites/default/files/poster_water_op_groene_daken_web.pdf
Additional investment costs of multifunctional roofs	Red roof investment costs	50	€ / m^2	Expert judgement
Additional investment costs of multifunctional roofs	Red roof replacement period	30	Year	Expert judgement
Additional maintenance costs roof[3, 4]	Regular roof	4	€ / m² per year	https://www.dakdekker-weetjes.nl https://www.dakdekker-weetjes.nl
Additional maintenance costs roof	Blue roof	1	€ / m² per year	https://www.homedeal.nl/dakbedekking/dakonderhoud-prijzen/
Additional maintenance costs roof	Yellow roof	3.50	€ / panel per 5 years	https://www.zonneplan.nl/kenniscentrum
Additional maintenance costs roof	Green roof	1.20 – 1.80	€ / m² per year	https://www.milieucentraal.nl/
Additional maintenance costs roof	Red roof	10	€ / m^2 per year	Expert judgement
Housing	Energy consumption per household	3,400	KwH / year	https://www.milieucentraal.nl/
Housing	Neighborhood typology	-	-	https://www.arcgis.com/home/item.html?id=9b0a61fcbcf140c3951c2272782f9474

[3] These are *additional* maintenance costs compared to the regular maintenance costs for the roof.
[4] This is a default value and can be changed by the user of the tool.

Housing	Current WOZ value	-	€	https://www.wozwaardeloket.nl/
Energy yield	Energy yield per solar panel	300	Wp	https://www.zonneplan.nl/kenniscentrum https://www.zonnepanelen-weetjes.nl/prijzen-zonnepanelen/
Energy yield	m^2 per panel (depending on the slope of the roof) • A flat roof can use 100% of space. • A gentle slope can use 80%. • A sloping roof can use 60% • A more sloping roof can use 40%	2.5	m^2	https://www.zonneplan.nl/kenniscentrum https://www.zonnepanelen-weetjes.nl/prijzen-zonnepanelen/
Energy yield	Correction coefficient for efficiency of solar panels	0.9	-	https://www.zonneplan.nl/kenniscentrum https://www.zonnepanelen-weetjes.nl/prijzen-zonnepanelen/
Energy yield	Price KwH electricity[5]. It is assumed that the generated energy is used for own consumption. If there is a surplus, it will be transferred back into the network. The generated electricity is valued for €0.22 per kWh.	0.22	€	https://www.zonneplan.nl/kenniscentrum https://www.zonnepanelen-weetjes.nl/prijzen-zonnepanelen/
Property value	Property values increase, dependent on the amount of surface in m^2: • 1.4% increase for green roofs smaller than 500 m^2 • 2.5% increase for green roofs smaller than 1000 m^2 • 5% increase for green roofs smaller than 2000 m^2 • 7.5% increase for green roofs smaller than 3000 m^2 • 10% increase for green roofs smaller than 4000 m^2 • 12.5% increase for green roofs smaller than 5000 m^2 • 15% increase for green roofs smaller than 6000 m^2 • 17.5% increase for green roofs smaller than 7000 m^2 • 20% increase for green roofs smaller than 8000 m^2 It is assumed that the property value increase occurs once in year 1.	1.4-20	% of the WOZ value	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3524597/

[5] Under the following assumption: the price for direct energy back to the grid is equal to the price for purchasing electricity.

Water retention	Shadow costs / avoided costs by an alternative water retention service.	500	€	7SE, 2017
Water retention	Default value for water retention of a green roof. The amount of water retention on a blue roof can be set manually.	10	mm	https://www.riool.net/referentieoppervlak-van-mm-naar-m³-en-terug
Water re-use	Price of drinking water. The collected water can be re-used for own consumption (for example irrigation of the green roof). It is assumed that this would avoid certain costs.	0.85	€ / m^3	TEEB-stad tool, 2019
Capturing fine particulate matter	Unit correction	3.1536	Cm / s to kg / ha / year	TEEB-stad tool, 2019
Capturing fine particulate matter	Deposition rate fine particulate matter green roofs	0.33	Cm / s	TEEB-stad tool, 2019
Capturing fine particulate matter	Social value fine particulate matter	45.22	€ / kg	TEEB-stad tool, 2019
Capturing fine particulate matter	Deposition rate nitrogen dioxide green roofs	0.5	Cm / s	TEEB-stad tool, 2019
Capturing fine particulate matter	Social value nitrogen dioxide	35.18	€ / kg	TEEB-stad tool, 2019
Capturing fine particulate matter	Deposition rate sulfur dioxide green roofs	0.72	Cm / s	TEEB-stad tool, 2019
Capturing fine particulate matter	Social value sulfur dioxide	25.24	€ / kg	TEEB-stad tool, 2019
Capturing fine particulate matter	Deposition rate ozone green roofs	0.75	Cm / s	TEEB-stad tool, 2019
Capturing fine particulate matter	Social value ozone	4.24	€ / kg	TEEB-stad tool, 2019
CO_2 emission and air quality (other emissions)	Avoided emissions CO_2 NOX SO2 VOS Fine particulate matter	 0.69 0.00071 0.00039 0.00056 0.00003	 kg/kWh kg/kWh kg/kWh kg/kWh kg/kWh	 NEV (2017) CE Delft (2014) CE Delft (2014) CE Delft (2014) CE Delft (2014)
CO_2 emission and air quality (other emissions)	Environmental prices CO_2 NO_X SO_2 VOS Fine particulate matter	 0.048 35 24.4 2.29 43.5	 Euro/kg Euro/kg Euro/kg Euro/kg Euro/kg	 CE Delft (2018)
Health (physical and mental)	Decrease in patients in 1000 inhabitants, within 1000m	0.835	Patients with 1% more green	TEEB-stad tool, 2019

Health (physical and mental)	Prevented healthcare costs	917	€ per patient	TEEB-stad tool, 2019
Health (physical and mental)	Prevented loss of work	6,679	€ per patient	TEEB-stad tool, 2019
Health (physical and mental)	Assumption: Fewer patients in 1000 inhabitants, within 200m	0.167	Patients with 1% more green	TEEB-stad tool, 2019
Health (physical and mental)	Assumption: Fewer patients in 1000 inhabitants, within 2000m	0.0334	Patients with 1% more green	TEEB-stad tool, 2019

6 LITERATURE

Overview key figures

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Overview qualitative benefits

Natuurpunten (nature points):
https://denhaag.raadsinformatie.nl/document/7416644/1/RIS301953_bijlage_het_rapport

BREEAM: https://www.breeam.nl/

COLOPHON

LIFE @ URBAN ROOFS 2.0
BACKGROUND REPORT KEY FIGURES

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DATE
21 May 2021

STATUS
Final

CHECKED BY

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