# IKO carrara

## Climate control on flat roofs

A STUDY INTO CLIMATE ANTICIPATION WITH
BITUMEN ROOF COVERINGS


IKO

# TABLE OF CONTENTS



# FOREWORD

Bitumen has long proven its worth in various waterproofing applications, and during the second half of the 20th century it evolved into a high-tech and highly reliable waterproofing membrane.

Thanks to continuous investment in research and development, IKO has perfected its membranes into high-quality products that respond to the changing environment. Since 2012, one of these achievements has been the revolutionary IKO carrara, a white, reflective and air-purifying roof membrane which, in addition to its various waterproofing capabilities, offers additional economic, social, technical and ecological advantages.

Climate change continues to highlight the urgent need to adapt the way we build. Weather is becoming more extreme: summers are getting warmer, winters are getting colder, storms are getting fiercer and rain and hail showers are getting more intense. The proverbial roof over our heads is our primary protection. As such, roofs require the necessary attention, and why not protect yourself from more extreme weather already?

Air quality and energy conservation are also social concerns these days.
We are trying to emit less toxic substances into the atmosphere, but with the IKO carrara roof membranes, we now also have the opportunity to purify polluted air, save more energy, and even generate it.

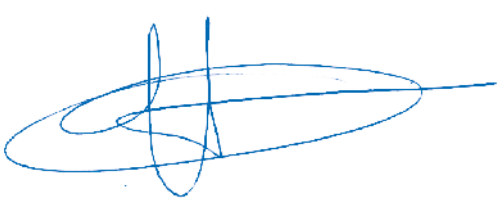
It sounds like magic, and it is…
Since the launch of the IKO carrara roof membrane several years ago, more than 1,000,000 m² of this product has been manufactured and installed throughout Europe.

This highly reflective roofing membrane has slowly but surely gained a foothold in the market. However, its many benefits have not been blindly accepted by an understandable conservative construction sector.

That's why our project managers put their heads together to put down their experiences and knowledge about IKO carrara on paper. This document is intended to give you a comprehensive insight into the advantages that the IKO carrara roof system has to offer for all interested parties. We hope that this work of reference will inspire building professionals to choose, prescribe and install the IKO carrara roof system.

Christoph Desmet
Project Manager

Paul Alenus
Commercial Director



# INTRODUCTION

For decades, climate scientists have been warning of the need to reduce greenhouse gas emissions, with one goal in mind: avoiding a warmer and less habitable future.
As the first signs of climate change are starting to show, the climate debate has taken centre stage in the public debate.
Governments are realising that designing energy-efficient buildings is a vital step towards preventing more drastic warming.
This is why the EU has introduced the NZEB concept, the Nearly Zero-Energy Building principle that will be regarded as the standard for new buildings from 2021.
However, that is not the end of the story; we also need to take the predicted changes into account, even if greenhouse gas emissions fall sharply.

More and more experts recognise that while we need to continue to do everything we can to slow down greenhouse gas emissions, we also need to start designing buildings that will work in a changing climate.
This document examines the science of global climate change, and how we can adapt the environment to a world which by the end of this century will be very different from the one we know today.

As such, an intelligent and well thought-out construction of the building shell is more than ever a priority, starting from today.

# SUMMARY

# 1. THE CHANGING CLIMATE

The key question for scientists is no longer 'if' we will experience climate change, but to what extent this change will manifest itself. The climate is getting more extreme: temperatures are rising, rain showers are becoming more intense, droughts are more frequent, snow and ice layers are melting, and sea levels are rising. Most of the global warming is very likely a result of the recorded high concentrations of greenhouse gaseswhich are due to human activities. For climate change to level off, we need to reduce these emissions, and ideally prevent them.

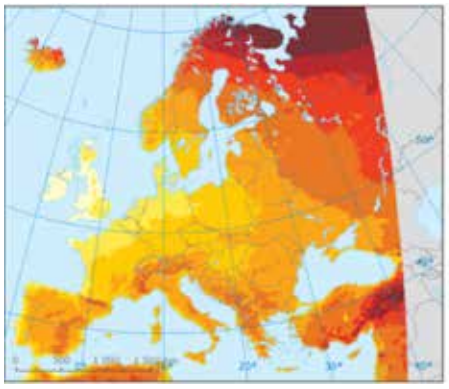
## 1.1 AIR QUALITY

The World Health Organisation has stated that more than 80% of the world's population in urban areas (with monitoring stations) are exposed to inadequate air quality. According to the Flemish Environment Agency (VMM, 2017), concentrations in Flanders are too high compared to the recommended values of the World Health Organisation, for:

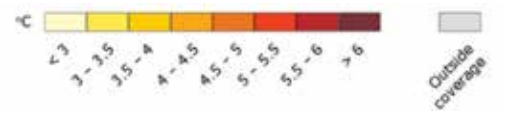
- ozone at all monitoring stations
- fine particles at almost all monitoring stations (PM 2.5 fraction at all monitoring stations, PM10 fraction at more than 80% of monitoring stations)
- sulphur dioxide at almost half of the measuring stations
- nitrogen dioxide and heavy metals at certain stations

## 1.2 AMBIENT TEMPERATURE

Studies by the European Environment Agency (EEA, 2015) show that Western Europe can expect an average temperature increase of 3 - 3.5°C over a period of 100 years. The study predicts summer periods with higher temperatures and less rainfall.



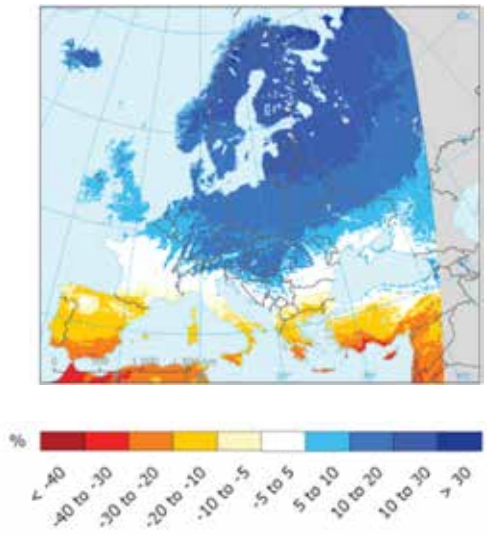
*Projected change in average annual temperatures*




*Projected change in average annual temperatures*

## 1.3 RAINFALL

The evolution of rainfall levels is region-specific. Northern Europe is expected to have significantly higher rainfall (+10-30%), while southern Europe will have much less rainfall (-10-30%). In Belgium, 5 to 10% more rainfall is expected, according to predictions by the European Environment Agency.




*Source: European Environment Agency (EEA, 2015)*

## 1.4 BUILDING DESIGN

The changing climate conditions require an adapted approach to the design of building shells. It is the social responsibility of architects, clients and contractors to apply a well thought-out building concept. To respond to climate change, IKO developed the carrara roofing membrane, a bituminous top layer which is applied in an ecological and sustainable roof concept.

# 2. IKO CARRARA ROOF CONCEPT

IKO carrara is a waterproofing membrane composed of a flexible elastomeric bitumen (SBS) with fire retardant properties, which meets all Broof classes t1-t4. The product is reinforced with a polyester-glass fibre inlay. The top side is finished with a white reflective granulate (SRI 79) with air-purifying titanium oxide.
This top layer can be applied in a single or multi-layer system, and can be applied in various ways.
The application is further explained in our White Paper 'Bituminous top layer'. Below we discuss the various economic, ecological, technical and social benefits that the Carrara roof system has to offer.


# 3. IKO CARRARA ROOF SYSTEMS

## COOL ROOF SURFACES UP TO 30 °C BETTER THAN OTHER ROOFING MEMBRANES

### 3.1 PROPERTIES

IKO carrara achieves a Solar Reflectance Index (SRI) of 79 thanks to a highly reflective white mineral finish.

### 3.2 BENEFITS

1. Higher efficiency of technical installations during warm periods.

   Thanks to its reflective qualities, IKO carrara provides a cooler environment on top of the roof. As a result, technical installations have a lower operating temperature, meaning that they consume less energy during hot and sunny periods.

2. Higher efficiency of solar panels during warm periods.

   Thanks to its reflective qualities, IKO carrara provides a cooler environment on top of the roof. The efficiency of solar cells increases during sunny periods, at a lower ambient temperature.

3. Longer lifespan.

   Thanks to its reflective qualities, IKO carrara reduces thermal extremes in the roof structure. As a result, the roof system enjoys enhanced stability and a longer service life.

4. Fewer cooling requirements in the building during warm periods..

   Thanks to its reflective properties, the IKO carrara can reduce heat radiation in the roof during warm, sunny periods, thereby reducing the need to cool the building down.

5. Preventing urban heat accumulation during warm periods.

   Thanks to its reflective qualities, the IKO carrara can also provide a lower ambient temperature in urban environments. On the one hand, this can ensure increased urban comfort, but on the other hand it also reduces ozone development.

6. Increased comfort for users of the building.

   Thanks to its reflective properties, the IKO carrara can reduce heat radiation in the roof during warm, sunny periods, allowing users of the building to enjoy a more pleasant indoor climate.

### 3.3 EXPLANATION

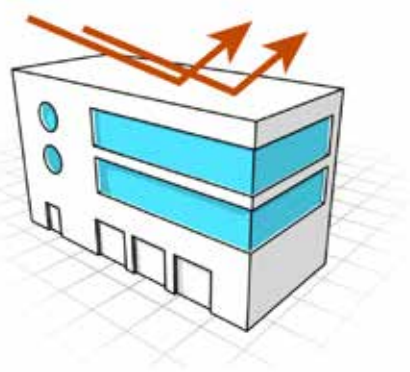
The sun is a vital source of energy. Of course, the intention is to harness this energy in the right way. Building shells need to be designed in such a way that the benefits of solar energy can be optimised, without the risk of overheating.

#### 3.3.1 REFLECTION AND TRANSMISSION

The IKO carrara has been extensively tested by OMT (Optical Measurements & Testing Materials for Optical Technology Thin Film Design and Analysis) with a Perkin Elmer spectrometer. This made it possible to identify the benefits of the white reflective and emitting mineral finish (OMT, 2015).

*Research has shown that IKO carrara can influence the temperature progression in and on the roof in two phases:*

## Temperature control phase 1: Reflection (SR)

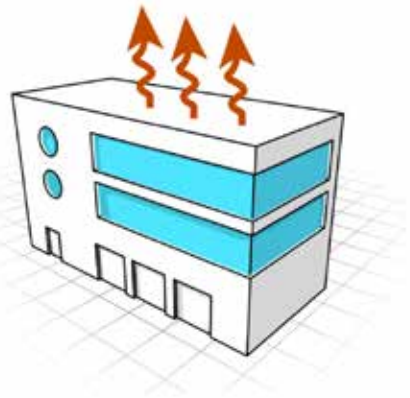


IKO carrara will reflect most of the radiant energy. That way, the received energy will be radiated back in the form of heat and light, and only a limited amount of this energy will be stored in the roof structure. As a result, overheating in summer can be prevented.

Solar reflection (also called albedo) is the ability of a given material to reflect solar energy from its surface back into the atmosphere. The SR (= Solar Reflection) value is expressed on a scale from 0 to 1. An SR value of 0 means that the material absorbs all solar energy, and a value of 1 means full reflection.

IKO carrara has a reflection of 0.65

## Temperature control phase 2: Emittance (E)



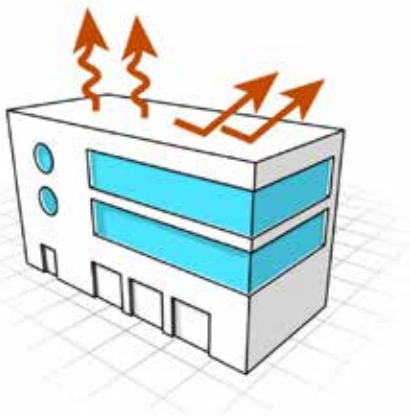
For the limited amount of energy that is nonetheless absorbed by the roof structure, it is important that this energy can leave the structure quickly. That way, IKO carrara ensures extremely limited heat peaks in and on the roof.

This phenomenon is expressed in terms of thermal emittance. Thermal emittance is the ratio of the heat emittance of a given surface compared to a standard black surface, which ideally has the highest heat emittance.

Emittance is expressed on a scale from 0 to 1. An emittance value of 0 means that the material does not release any absorbed energy and a value of 1 means that it releases all the heat.

IKO carrara has a thermal emittance of 0.92

## SRI (Solar Reflectance Index)



The SRI is a measure of the relative temperature of a surface in a stable condition, in relation to a standard white surface (SRI 100) and a standard black surface (SRI 0) according to predetermined environmental parameters. The SRI value is determined in accordance with ASTM E1980. The SRI is not a temperature scale (since a rising SRI causes a decrease in the surface temperature of the test surface) but rather a coolness scale, whereby SRI = 0 is as warm as standard black and SRI = 100 is as cool as standard white. The SRI can be smaller than 0 or larger than 100.

The SRI is calculated as follows:

$$SRI = 100 \frac{T_b - T_s}{T_b - T_w}$$

Ts surface temperature of the test surface in a stable condition
Tb surface temperature of a standard black surface in a stable condition
Tw surface temperature of a standard white surface in a stable condition
(all temperatures expressed in Kelvin)

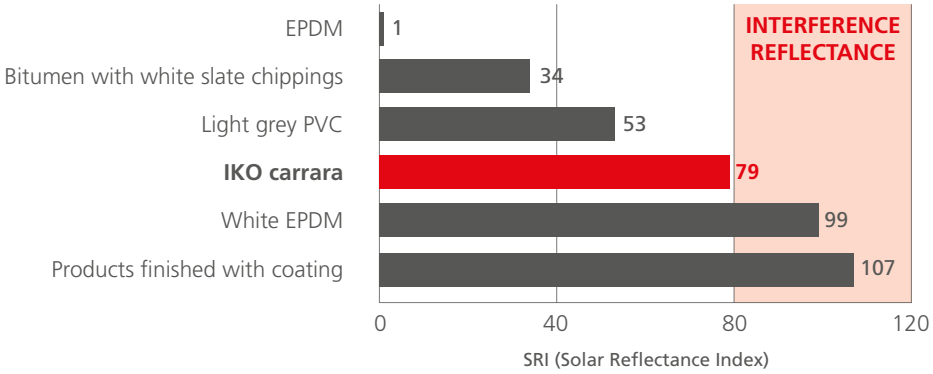
IKO carrara has a SRI score of 79

Thanks to its high reflectance (SR), the IKO carrara roof membrane will absorb very little heat, and the limited amount of heat absorbed will quickly be emitted (E). Urban environments affected by the heat island effect can tackle urban heat development effectively, with reflective membranes.

### 3.3.2 COMPARISON OF THE SRI VALUES OF VARIOUS ROOF COVERING SYSTEMS

Different roof coverings have different SRI values. A black roofing membrane has a low reflectance value (SR) and consequently shows a higher surface temperature and a low SRI. For roof membranes with a lighter finishing colour, we observe a lower surface temperature. Of course this goes hand in hand with a higher SRI score.

**SRI values of roof coverings**




Please note:

A too high reflectance index (> 82) should be avoided. A too high SRI can cause reflection nuisance to neighbours, disturb the orientation of migratory birds, and dazzle or distract air traffic. IKO carrara roofing membrane is designed to achieve the optimum balance between efficiency and limiting the environmental impact. The available product data show that the obtainable reflective roof coverings have highly divergent reflective values:

| Product group | Product type | Emittance (E) | Reflectance (SR) |
|---|---|---|---|
| EPDM | Black | 0.88 | 0.07 |
| | Grey | 0.87 | 0.23 |
| | **White** | **0.84** | **0.80** |
| TPO | Grey | 0.88 | 0.43 |
| | **White** | **0.89** | **0.88** |
| PVC | Grey | 0.81 | 0.48 |
| | **White** | **0.89** | **0.86** |
| Bitumen | Black | 0.92 | 0.26 |
| | White (slate chippings) | 0.92 | 0.32 |
| | **White ($TiO_2$ granulate)** | **0.92** | **0.65** |

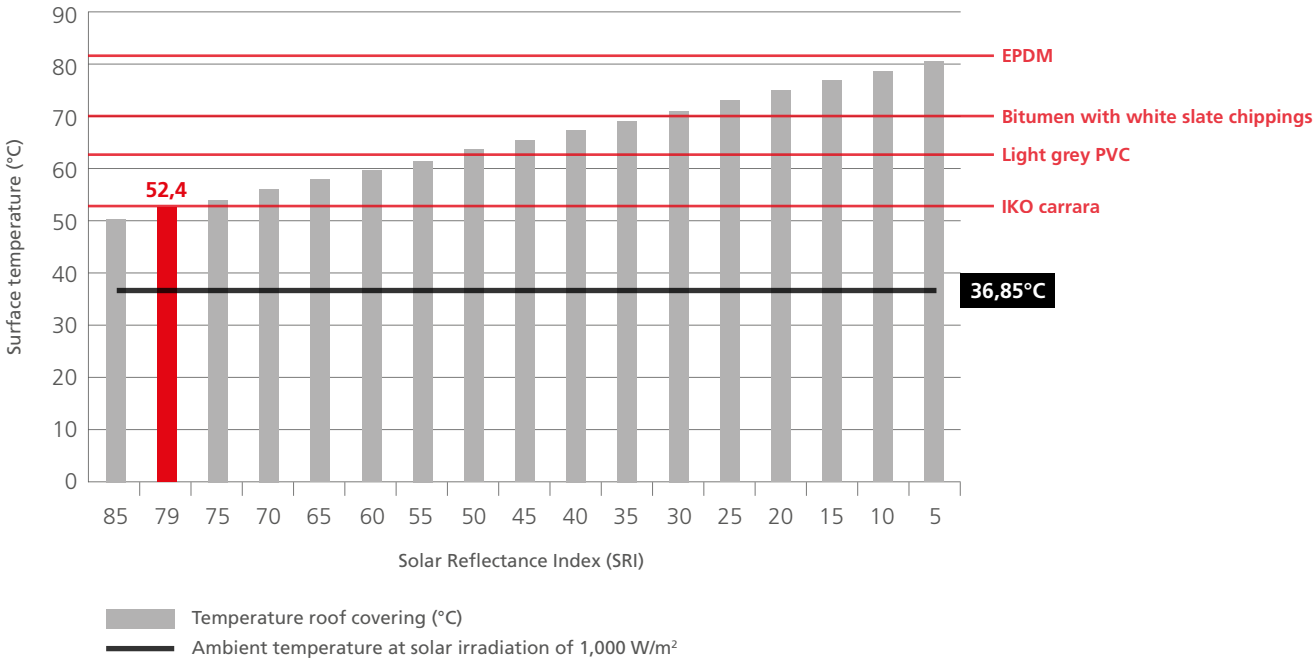
Source: Cool Roof Rating Council - CRRC (2017)

The thermal emittance (E) is primarily related to the structure of a given surface, while the reflectance (SR) is primarily related to the finishing of a given surface. In general, bituminous roof coverings have a better thermal emittance (E) than plastic materials.
Thanks to its favourable emittance value, IKO carrara achieves the most optimal SRI value without causing problematic reflection.

### 3.3.3 SURFACE TEMPERATURE VERSUS SRI VALUE

The SRI values of various roof membrane types make it possible to compare their respective surface temperatures under identical conditions, as laid down in the standard ASTM E1980 (ASTM, 2001). According to this standard, IKO carrara, with a SRI of 79, has a maximum surface temperature of 52.4°C on a hot summer's day.

**Surface temperature of roof membrane according to SRI**
**(conform ASTM E198)**



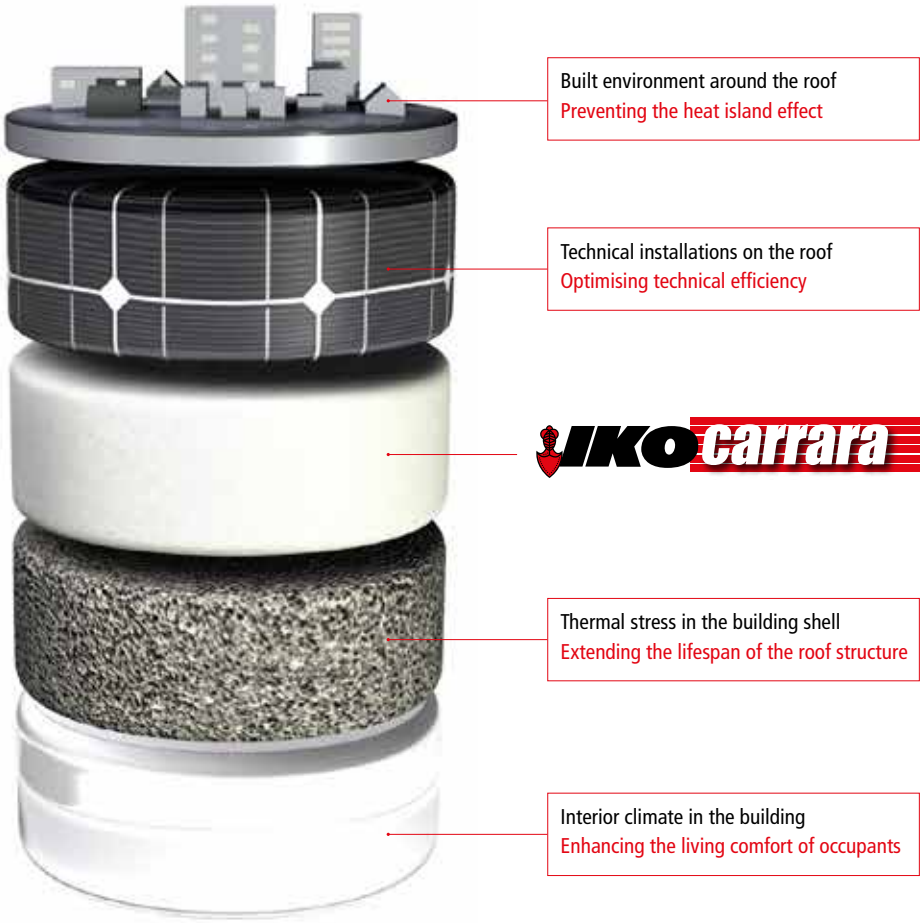

Compared to IKO carrara, standard roofing systems score between 19 and 56% lower in terms of surface temperature.

| Roof covering | SRI | Surface temperature | Heating |
|---|---|---|---|
| IKO carrara | 79 | 52,4 °C | Base |
| Light grey PVC | 53 | 62,6 °C | + 10,2 °C **(+ 19,5%)** |
| Bituminous membrane with white slate chippings | 34 | 69,6 °C | + 17,2 °C **(+ 32,8%)** |
| Black EPDM | 1 | 82 °C | + 29,6 ° C **(+ 56,5%)** |

The advantages of a reflective roof covering are further discussed in the following sections.

### 3.3.4 TEMPERATURE CONTROL ON 4 LEVELS

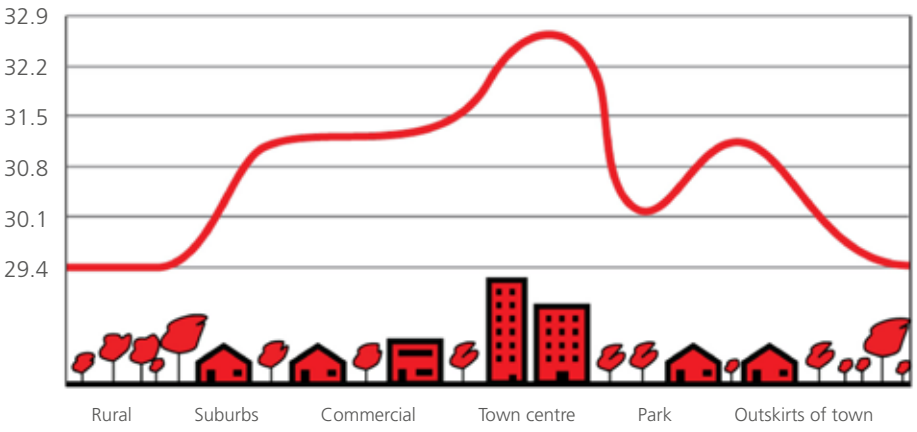
A reflective roof covering can control the temperature at 4 levels.
This is further explained below.




Temperature control: The 4 levels of temperature control on a IKO carrara roof

## A. THE BUILT ENVIRONMENT

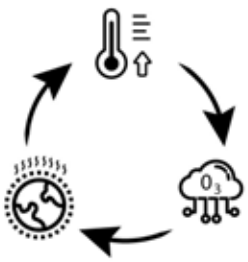
The urban heat island effect (UHI) is a phenomenon whereby the temperature in urban areas is warmer on average than in adjacent rural areas. The main causes of this phenomenon are, firstly, the absorption of sunlight by the dark building materials used in the city and, secondly, the more limited wind speeds.




The heat island effect leads to uncomfortable ambient temperatures in urban areas.

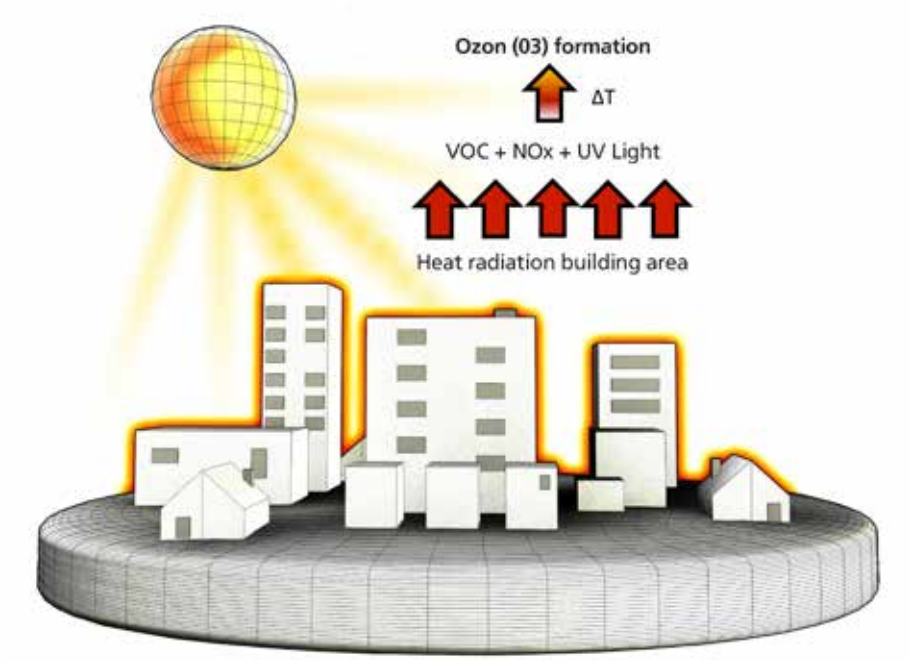
The heat island effect has a negative impact on:

- living comfort in the urban environment: additional heat stress occurs during heat waves. A comfortable temperature for an average person doing light exercise is between 20 and 30°C, with air humidity of 35 to 60% (Brussels Environment, 2007).
- public health: heat waves in urban areas entail various health risks for vulnerable population groups.
- the greenhouse effect: the higher ambient temperature accelerates the formation of local ozone or smog. Smog in the stratosphere restricts plant growth and the neutralisation of $CO_2$.




The heat island snowball effect:
higher ambient temperatures facilitate the formation of ozone in the stratosphere, thereby increasing the greenhouse effect.
Global warming in turn further magnifies this whole process.

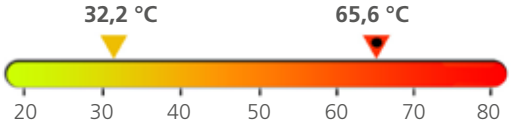
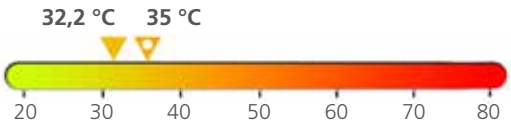
Urban development measures are required to limit the heat radiation of buildings.




Heat accumulation in cities contributes to the formation of harmful ozone in the stratosphere.

## IKO carrara, the solution for cooler cities

By designing buildings with IKO carrara roof coverings, we are tackling both the heat island effect and global warming. Thanks to its reflective qualities, IKO carrara absorbs less energy from sunlight, and emits it more quickly. The considerable added value of a reflective roofing membrane can be appreciated on a summer's day:

| | Ambient-temperature | Surface-temperature | Ambient temperature vs. surface temperature |
|---|---|---|---|
| Traditional roof (dark granulate) | 32,2 °C | 65,6 °C |  |
| Cool roof (membrane with reflective granulate) | 32,2 °C | 65,6 °C |  |





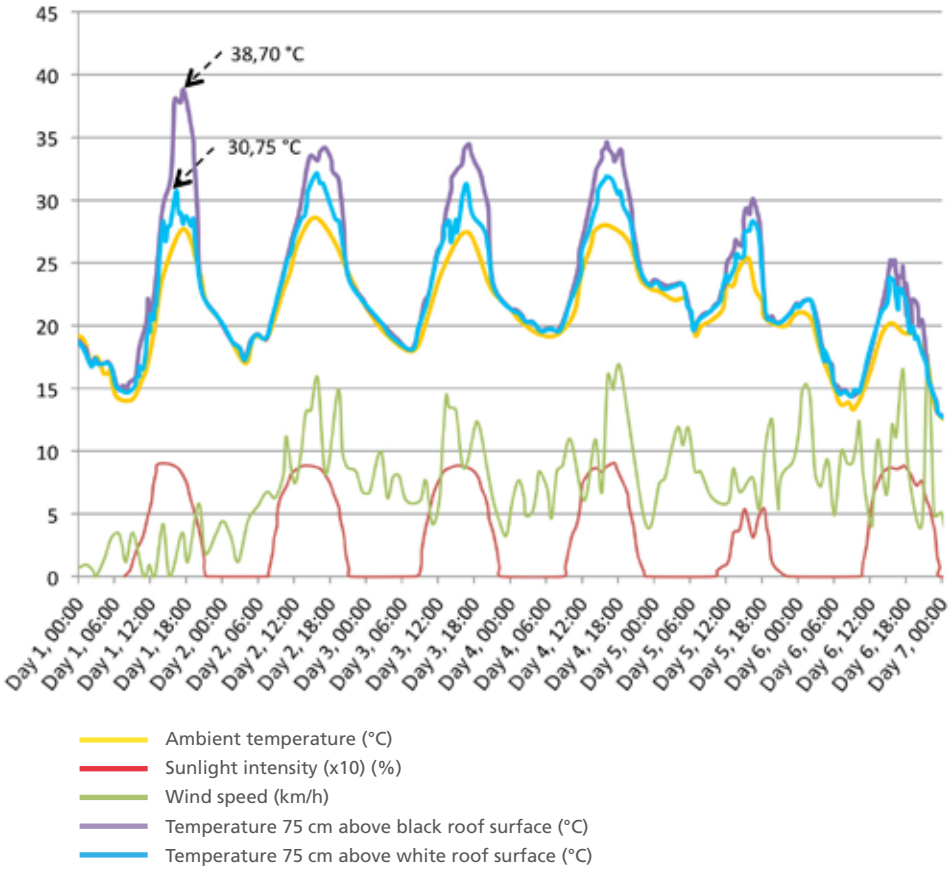
(U.S. Department of Energy, 2017)

Research by the US EPA (Environmental Protection Agency), the federal agency responsible for protecting public health and the environment, shows that traditional roof coverings reach peak temperatures of up to 82°C on warm and sunny days, while reflective roof coverings reach a maximum peak temperature of 49°C under the same conditions. This is a temperature difference of fully 33°C (US EPA, 2011).

## B. TECHNICAL INSTALLATIONS ON THE ROOF

In addition to the temperature in the environment around the roof as discussed above, the temperature on top of the roof also needs to be taken into account. The temperatures on top of the roof have a significant influence on the technical installations present. Below we discuss the temperature cycles that can occur at 75 cm above the roofing membrane and the consequences for the energy consumption or energy generation of the technical roof installations (HVAC, PV).

**Temperature cycle above flat roofs (H = 0.75m)**

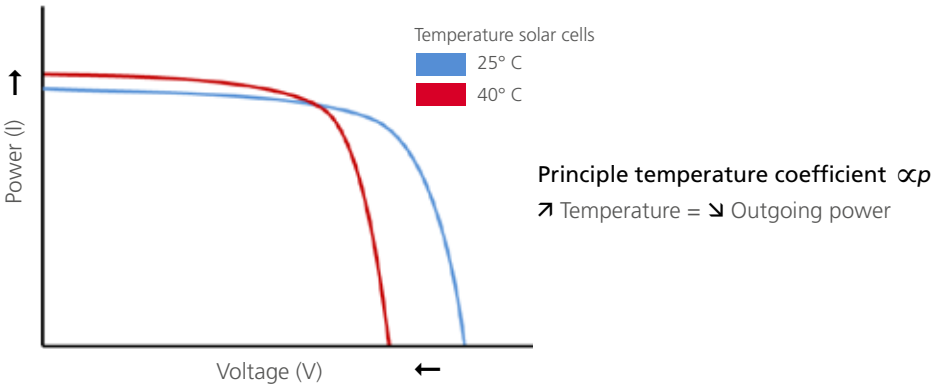



We can observe that the temperature on top of the roof is much lower with a reflective roof covering, primarily on very sunny days with little wind.

In the following sections, we discuss the influence of heat on technical installations located on flat roofs.

## C. PHOTOVOLTAIC INSTALLATIONS

A white roof covering increases the yield of solar panels on a flat roof.
The yield is influenced by a number of factors, including the amount of sunlight on the roof, the orientation of the roof, the influence of wind, and in particular: the ambient temperature.




Solar cells and other technical installations such as air conditioning and ventilation units will perform better, due to the significantly lower ambient temperature on the roof. The cooling of areas under a flat roof is also less frequent, as the roof membrane absorbs less heat and conducts it to the underlying roof structure.
This has a direct impact on the energy consumption (HVAC) or energy yield (PV) of technical installations on the roof.

If the temperature of solar cells rises above 25°C, the output current (I) rises slightly but the voltage (U) falls more sharply. The temperature increase ultimately results in a smaller yield, in this regard we refer to the above-mentioned I(U) curve (Electropaedia, 2017).

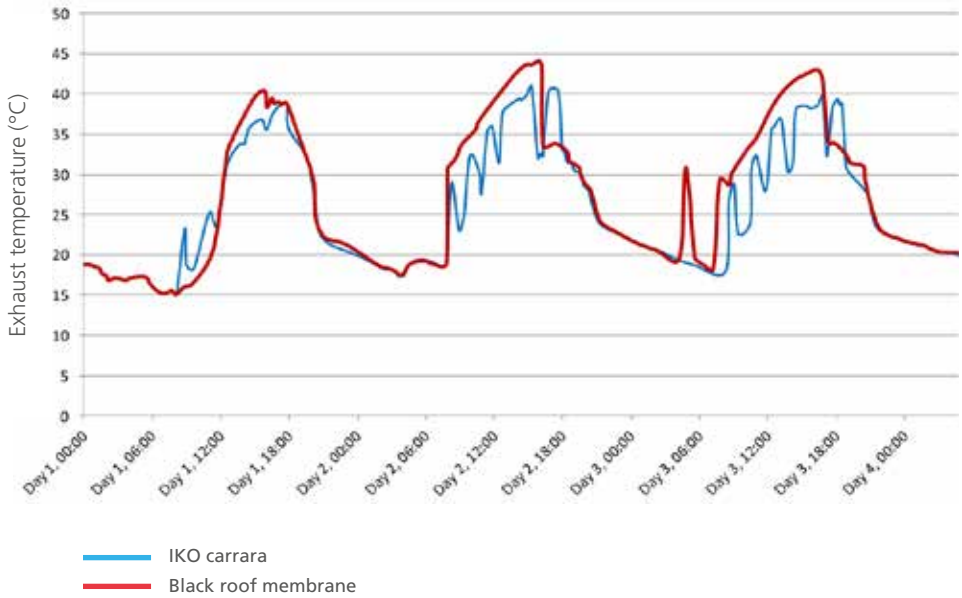
The frequently used silicone panels (mono crystalline silicone) have a temperature coefficient $\alpha p$ of around -0.4 to -0.5% on the maximum capacity Pmax. This means that for every additional degree Celsius above 25°C,the output power, expressed in watts, decreases by 0.4 to 0.5%. At 35°C a 40W solar panel with a temperature coefficient of -0.4 will produce less than 38W (Agroui, 2011).

Research also shows that the temperature coefficient degrades as the solar cells age, which implies that the indicated temperature coefficient would only be applicable for newly installed solar panels (Mahmood, 2017). The influence of temperature on the efficiency of the solar panels therefore increases over the years.

## D. HVAC

Not only will a white roof covering increase the yield of a PV installation, but the consumption of ventilation devices on the roof also depends on the type of roof covering. The illustration below makes this easier to understand:

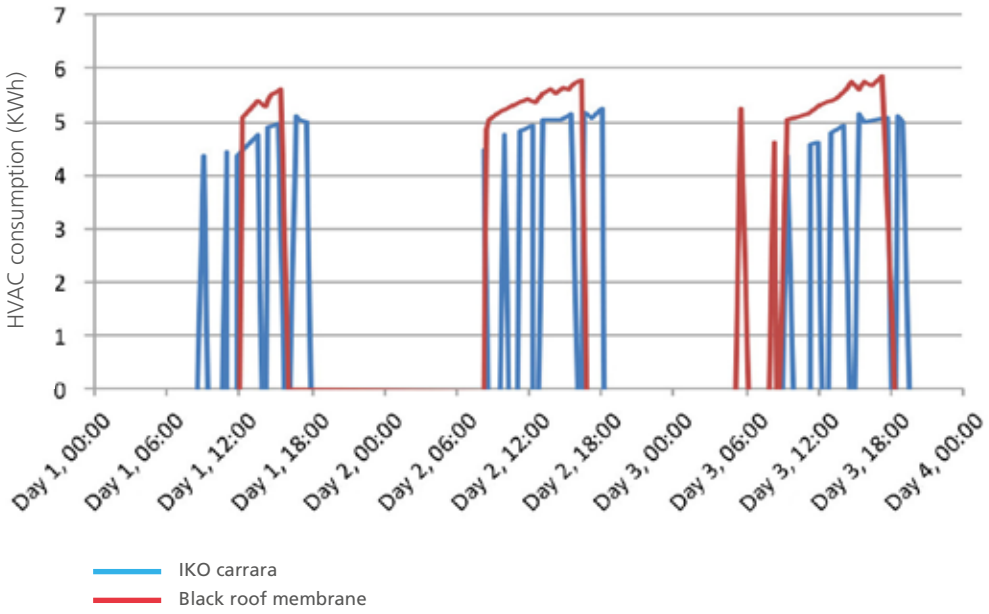
**Exhaust temperature HVAC units**




The above curve shows the temperature evolution of the compressor exhaust of two identical HVAC installations installed on top of the same building in the same time period. One HVAC installation was installed above a traditional black roof covering, and one HVAC unit was installed on top of an IKO carrara roof covering.

We observed that the compressor exhaust temperature was 13.7°C lower for the HVAC installation installed on top of the IKO carrara. The exhaust temperature of these installations is related to the energy consumption of the respective units. We refer to the below chart in this respect.

**Energy consumption HVAC units on flat roofs**




If we compare the electricity consumption of the two installations, we see lower consumption on the reflective roof. The installation on the Carrara roof consumes ± 0.8 kW less than the same installation on top of a black roof. **This HVAC installation consumes 16% less kilowatt hours (kWh) on a roof with IKO carrara under the same conditions.** The daytime temperature varied between 25°C and 27°C at the time of measurement (see ambient temperature curve page 20).

### Please note:

Due to the stricter insulation standards, the roof structure conducts less heat and the outer shell of flat roofs warms up more strongly. It is therefore important to consider choosing a suitable roof membrane with limited heat absorption.
This has a direct effect on the energy consumption of HVAC installations.

## E. THERMAL STRESS IN THE BUILDING SHELL

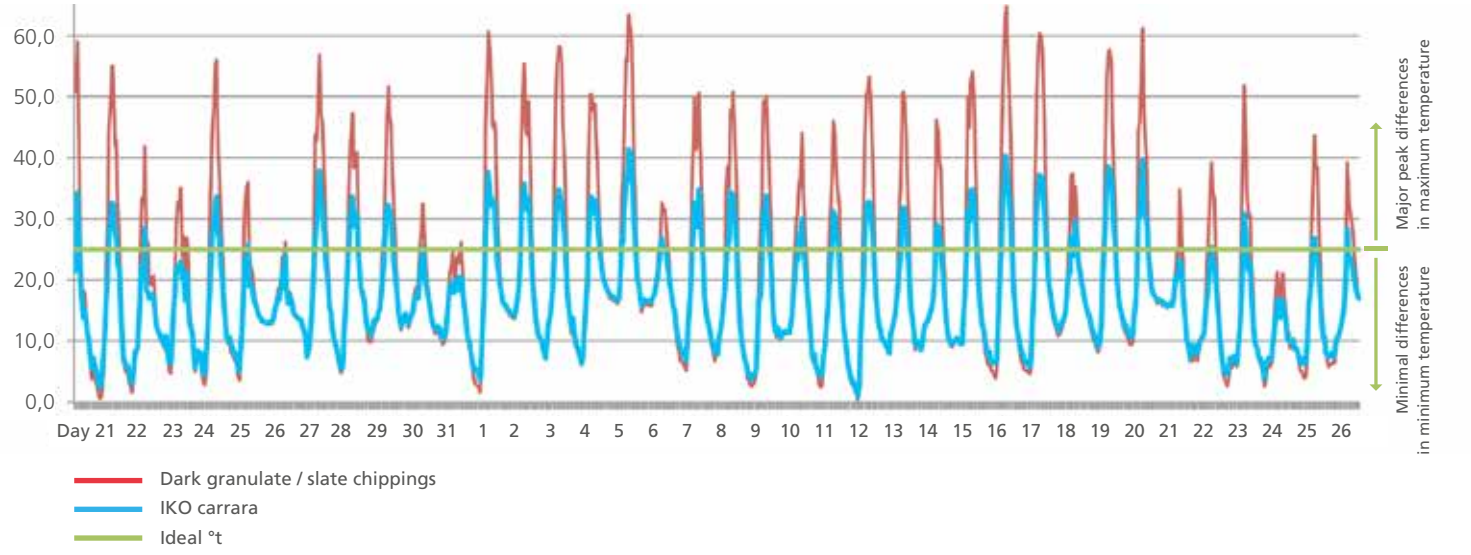
When exposed to extreme temperatures, a flat roof with a reflective roof membrane will be less susceptible to temperature shocks. Naturally this is advantageous for its lifespan.

Since most roofs have an insulation layer, this insulation layer will prevent heat transmission to the inside of the building. However, this means that the membrane is subject to stronger temperature shocks. That is why you should choose a suitable reflective roof membrane that minimises temperature shocks.

The first results of an ongoing internal study into the effects of limited temperature fluctuations in the roof covering indicate an extension of the utilisation phase of the membrane of 10%.

This means that IKO carrara lasts at least 4-5 years longer than traditional alternatives.

**Temperature cycle on the roof membrane (H = 0m)**





## F. INTERIOR CLIMATE IN THE BUILDING

In the summer, a reflective roof covering can provide excellent added value to buildings in terms of comfort. An IKO carrara roof system can ensure lower air temperatures in the building thanks to a lower surface temperature. If the building is equipped with active cooling (ventilation), a reflective roof covering can provide energy gains when the building is cooled.

### F.1 Comfort

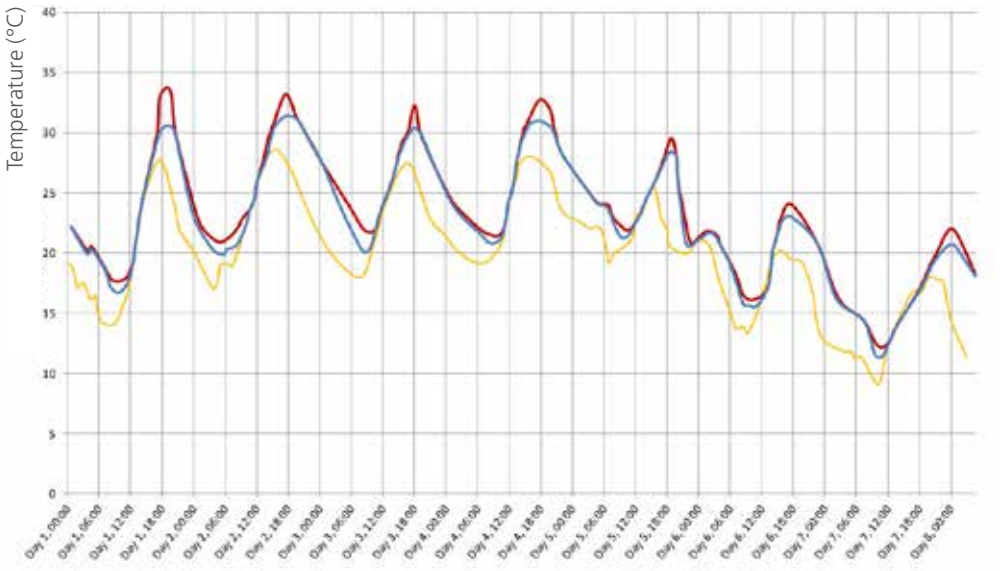
A recent study by the BBRI and the UCL among 149 homeowners has shown that living rooms and bedrooms can feel uncomfortable during the summer. More than 60% of homeowners said that the indoor temperature in these rooms was 'slightly too hot' or even 'too hot'. The study concludes that the necessary emphasis should be placed on correct building design on the one hand, and correct building use on the other (BBRI, 2017).

There are various measures that can be taken to limit the overheating of buildings:

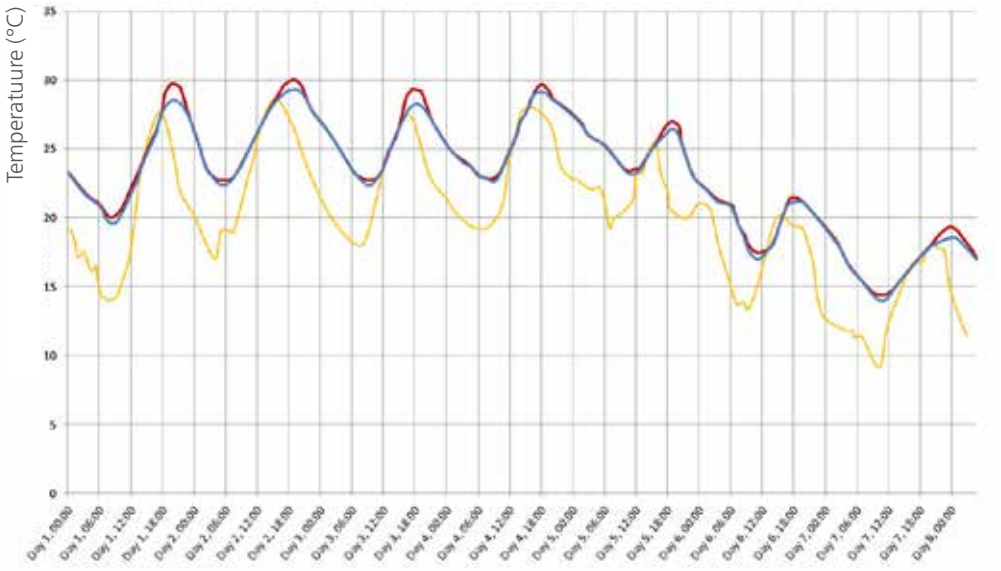
| Building design | User |
|---|---|
| Insulation | Natural ventilation |
| Sun blinds | ZSun blinds |
| Reflectance building shell | |
| Orientation | |
| Active ventilation | |
| Inertia | |

Applying a reflective roof covering is therefore one aspect of a well thought-out building design, to limit overheating. The extent to which a reflective roof covering helps prevent overheating depends on other factors in building design, as well as user behaviour. However, it is essential to pay adequate attention to the roof in building design, since a roof receives approximately 4 times more radiation (kWh/m²) from the sun than the walls.
Below, we look at the impact of a reflective roof covering in combination with two insulation thicknesses on a wooden support. That way, we can also get an idea of the impact of the thickness of insulation. This data was produced by a calculation simulation based on an Australian study by the University of Melbourne (University of Melbourne, 2011).

### Interior temperature vs. ambient temperature at insulation value R 1,2 m²K/W (± 3 cm PIR)




### Interior temperature vs. ambient temperature at insulation value R 4,5 m²K/W (± 10 cm PIR)




Ambient temperature (°C)
Interior temperature black roof covering
Interior temperature IKO carrara

With a minimum insulation thickness (3 cm PIR), we can observe that a reflective roof covering proves its added value especially in the late afternoon and the evening, when the sun has warmed up the building for several hours. During the summer, the peak difference in room temperature is between 1°C and 3°C lower compared to traditional black roof coverings.

A study carried out in Philadephia produced similar results, that installing insulation and a reflective roof covering can lower the average maximum daily surface temperature of the ceiling in summer by approximately 2.6°C, and the average daily maximum room temperature in summer by approximately 1.3°C. This study concludes that this temperature control in summer significantly improves the living comfort of the occupants (Blasnik, 2004).

Various studies also show that the roof temperature has an important influence on the thermal performance of the insulation materials present. For example, it has been demonstrated that certain insulation materials are up to 35% less effective at a surface temperature of 40°C than at a surface temperature of 24°C (Budaiwi et al, 2002). As such, the thermal performance of roofing insulation is better guaranteed in summer when combined with reflective roofing.

By incorporating a reflective roof covering combined with a more effective insulation layer, we can observe 3 phenomena in the interior climate:

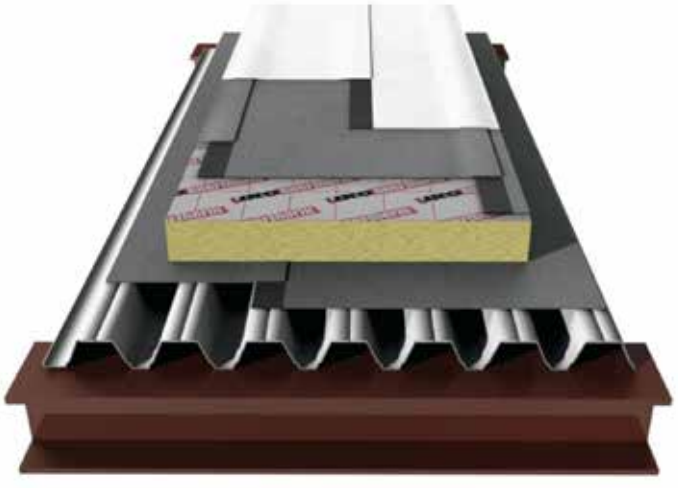
- a slight shift in phases: thanks to the additional insulation, the roof structure is able to buffer more heat. The result is that the heat slows down and radiates into the interior.
- more limited amplitude: thanks to the additional insulation, the roof structure insulates better against heat. This reduces the difference between minimum and maximum temperatures. This means that the sinusoidal curve is smoothed out by additional insulation.
- a smaller peak difference: installing a reflective roof covering still generates added value, albeit to a lesser extent. With an insulation thickness of 10 cm PIR, the (interior) temperature difference at peak moments varies between 0.5°C and 1.5°C.

### F.2 Energy savings with active cooling

As demonstrated, a cool roof will limit the need for additional cooling in the building, but may increase the need for additional building heating on certain days. Scientists have indicated that cool roofs primarily generate significant energy savings in buildings where both cooling and heating are needed. Each building needs to be assessed individually in terms of location, energy consumption, energy cost, roof structure, building type and environment.

We will make a concise simulation below with the following data:

| Energy management data | |
|---|---|
| Building warming | Natural gas boiler - High efficiency |
| Cost of natural gas per kWh | 0.05 EUR/kWh |
| Building cooling | Air conditioning - High efficiency |
| Cost of electricity per kWh | 0.29 EUR/kWh |



| Details of roof structure | |
|---|---|
| Roof covering | IKO carrara |
| R value roof structure | 1 m²K/W \| 4.5 m²K/W |
| U value roof structure | 1 W/m2K - 0.22 W/m²K |
| Reflection value roof membrane | 0.65 (SR) |
| Emittance value roof membrane | 0.92 (E) |
| SRI roof membrane | 79 |

| Region | Belgium[1] | | (Southern) France[2] | | Germany[3] | | Estonia[4] | | United Arab Emirates[5] | |
|---|---|---|---|---|---|---|---|---|---|---|
| Degree days to be heated (< 18°C) | 2815 degree days | | 1283 degree days | | 3087 degree days | | 4257 degree days | | 55 degree days | |
| Degree days to be cooled (> 21°C) | 74 degree days | | 350 degree days | | 129 degree days | | 33 graaddagen | | 2969 degree days | |
| Annual average solar irradiation per day | 2,95 kWh/m² | | 4,14 kWh/m² | | 2,67 kWh/m² | | 2,65 kWh/m² | | 5,48 kWh/m² | |
| **Insulation value roof (m²K/W)** | **R 1** | **R 4,5** | **R 1** | **R 4,5** | **R 1** | **R 4,5** | **R 1** | **R 4,5** | **R 1** | **R 4,5** |
| Cooling load (kWh/m²/jaar) | | | | | | | | | | |
| - IKO carrara | 1,68 | 0,40 | 9,86 | 2,31 | 2,61 | 0,62 | 0,68 | 0,16 | 74,44 | 17,88 |
| - Dark roof | 4,44 | 1,08 | 25,49 | 6,20 | 6,90 | 1,68 | 1,80 | 0,44 | 194,73 | 47,98 |
| Heating load (kWh/m²/jaar) | | | | | | | | | | |
| - IKO carrara | 87,53 | 22,27 | 49,50 | 12,88 | 92,96 | 23,58 | 115,38 | 29,08 | 2,59 | 0,69 |
| - Dark roof | 75,86 | 19,38 | 42,95 | 11,23 | 80,63 | 20,54 | 100,85 | 25,49 | 2,25 | 0,60 |
| Annual saving on cooling (EUR/m²) | 27,20 | 6,78 | 154,12 | 38,37 | 42,24 | 10,53 | 11,08 | 2,76 | 1186,15 | 296,90 |
| Annual saving heating (EUR/m²) | -7,44 | -1,84 | -4,18 | -1,06 | -7,86 | -1,94 | -9,27 | -2,29 | -0,21 | -0,05 |
| **Net annual saving (EUR/m²)** | **19,76** | **4,94** | **149,95** | **37,32** | **34,38** | **8,59** | **1,81** | **0,47** | **1185,94** | **296,85** |
| **Net annual saving (EUR/100 m²)** | **1.976** | **494** | **14.995** | **3.732** | **3.438** | **859** | **181** | **47** | **118.594** | **29.685** |

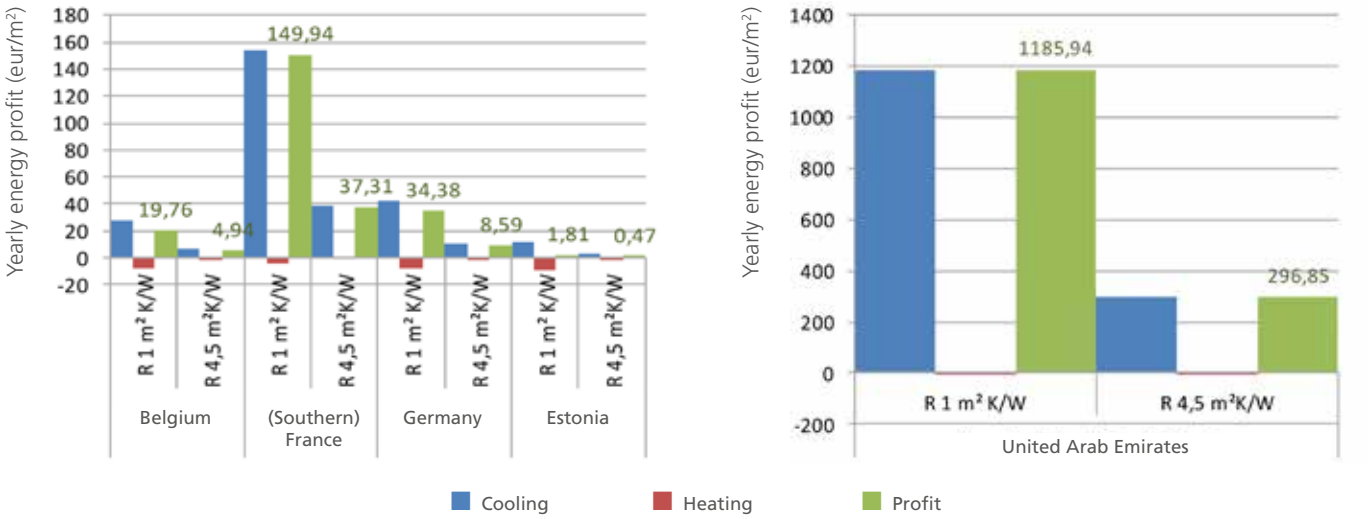
(1) Brussels International EBBR weather station
(2) Nice LFMN weather station
(3) Leipzig-Schkeuditz EDDP weather station
(4) Tallinn EETN weather station
(5) Abu-Dhabi OMAA weather station

This calculation method is based on research by the Oak Ridge National Laboratory, a division of the US Department of Energy. The main parameters in this calculation are the degree days and the average daily solar radiation of the roof on an annual basis (US Department of Energy, 2002).

The degree days system is a quantitative indexing system that enables energy specialists to gain insight into the energy needs of buildings. To determine whether it concerns degree days to be cooled or heated, we base ourselves on the average daily temperature(= (highest + lowest temperature)/2). Every day with an average temperature below 18°C results in a number of heated degree days. The cooled degree day (summer period) is the counterpart to the heated degree day (winter period). A daily average above 21°C results in a number of cooled degree days. Degree days are calculated in a given time period (usually one year) by adding the differences between the average daytime temperatures and the standard temperature of 18°C (winter) or 21°C (summer). For example, three consecutive winter days with average temperatures of 4°C, -2°C and -4°C result in 56 heated degree days.

And according to the same principle, three summer days of respectively 26°C, 28°C and 30°C result in 21 cooled degree days.

Monitoring degree days over time offers the opportunity to assess energy consumption and the resulting costs.




From the analysis, we can infer that the IKO carrara, thanks to its reflectance, generates significant net savings in various regions. The research shows that the amount of energy savings from a reflective roof covering primarily depends on:

- the thickness of the insulation: the thicker the insulation, the more the energy savings are smoothed out. However, even with 10 cm PIR insulation, considerable annual savings can still be made.
- the amount of cool degree days: the warmer the region the more energy saved, but even in a colder region such as Estonia, a significant amount of energy can still be saved.

We can therefore conclude that installing a reflective roof covering can generate added value in both cold and warm regions. Scientific research has shown that there are no significant differences between a black roof covering and a reflective roof covering in terms of interior temperature during winter periods.
It is assumed that this is due to the limited amount of sun radiation, owing to a large amount of overcast days during this season. Both computer simulations and test results confirm that insulation in the roof structure has the most influence on the interior temperature during winter periods. Using reflective roofing has a negligible influence on the interior climate in winter. That is why the energy savings with active cooling in the summer outweighs any additional heating of the building in the winter (see image above).

The above-mentioned research results cannot be generalised, since the efficiency of a reflective membrane is determined by various factors, including:

- The efficiency of the heating installation
- The cooling in the building and its efficiency
- The inertia of the building
- The position of the building and the irradiation of the roof
- The local energy prices
- The insulation value of the roof

**F.3 Higher productivity via passive cooling**

If the building is not equipped with active cooling (air conditioning), the temperature difference achieved in the building still translates into a significant increase in comfort.

Enhancing comfort is an opportunity to increase the productivity of people and business processes. Reflective roofing membranes create better working conditions by providing a more stable ambient temperature in work areas.

This is an important consideration, given that a large proportion of buildings in the production and distribution sector are not equipped with active cooling, are barely insulated, and even have limited ventilation. Most of these buildings have black roof coverings.

Building costs are the second largest cost item after staff costs (Oseland, 1999). In many cases, a company pays up to 100 times the cost per m² for staff compared to the energy cost per m². Every employee works an average of 5 minutes per day to cover energy costs (BOMA, 1998).
A slight increase in staff productivity can therefore result in much greater cost savings than a substantial increase in energy savings. For example, a 1% increase in productivity can equate to the total energy cost of the company's premises.

Various studies have been carried out into the relationship between thermal comfort and productivity in office buildings and production units, which have shown that:

- machine operators performing physical work are 10% less productive at an ambient temperature of 28.5°C, and 38% less productive at an ambient temperature of 35°C (Schweisheimer, 1962).
- higher productivity can also be achieved without air conditioning, by using passive cooling techniques(Liddament, 1996).
- improved physical environmental conditions (such as thermal comfort) can bring about a productivity increase of up to 15% (Oseland et al, 1999).

# 4. IKO CARRARA ROOF SYSTEMS
## PURIFYING HARMFUL SUBSTANCES IN THE AIR

### 4.1 PROPERTIES
IKO carrara neutralises sulphur and nitrogen dioxide thanks to its $TiO_2$ granulate finish.

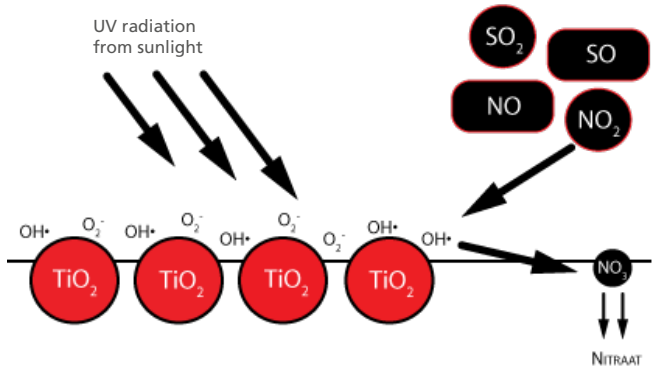
### 4.2 BENEFITS
**Healthier living environment for people and the environment.**
Thanks to the air-purifying action of the $TiO_2$ granulate, the formation of fine particles and ozone can be limited. Inhaling fewer fine particles and less ozone stimulates the proper functioning of the airways, lungs, heart and blood vessels.

### 4.3 EXPLANATION
Air quality is primarily determined by the concentrations of ozone, nitrogen dioxide ($NO_2$), sulphur dioxide ($SO_2$) and fine particles.

The ecological top layer, IKO carrara, contributes to air quality thanks to the titanium dioxide ($TiO_2$) present on the granulate on top of the roofing membrane.

$TiO_2$ has applications in a wide range of industries (construction, food, medicine, etc.) due to its purifying and self-cleaning properties.

On flat roofs, titanium dioxide converts harmful sulphur and nitrogen dioxide into harmless salts.




Titanium dioxide converts No (x) to harmless nitrates under the influence of UV.

The nitrogen ($NO_2$) and sulphur ($SO_2$) present in the air are converted into salts, with titanium dioxide as a catalyst under the influence of UV radiation ($NO_2$). The salt formed can then be washed away during a rain shower via the rainwater drain. The converted salts have no influence on the quality of the surface water and form nutrients for fauna and flora.

**Please note!**

As a catalyst, titanium dioxide affects the speed of the air-purifying reaction, without being consumed itself. This is not the case for all air-purifying substances: olivine is weathered over the years by binding to carbon dioxide ($CO_2$).

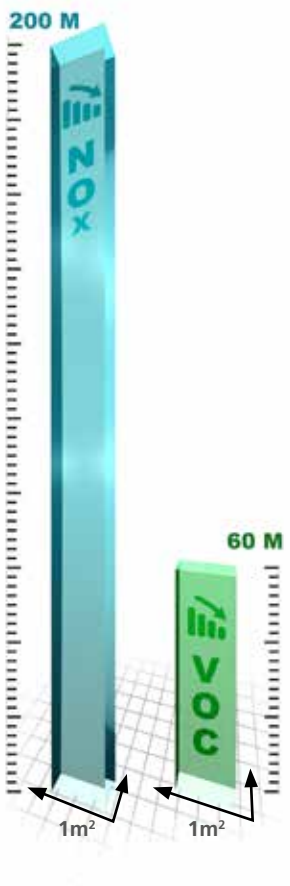
### 4.3.1 SPEED AND VOLUME OF AIR PURIFICATION

Research by the Lawrence Berkeley National Laboratory (CEC, 2008) has shown that every square metre of titanium dioxide can purify about 200 m³ of air from nitric oxides (NOx) per day, and 60 m³ of air from volatile organic compounds (VOC) per day.

The illustration on the right illustrates, to scale, what this equates to for a building with a roof area of 300 m². This roof has the potential to purify 60,000 m³ nitric oxides from the air and 18,000 m³ volatile organic compounds from the air every day.

This is potential volume of air purification per day, which is determined by various factors including the distribution and molecular state of the air pollution.

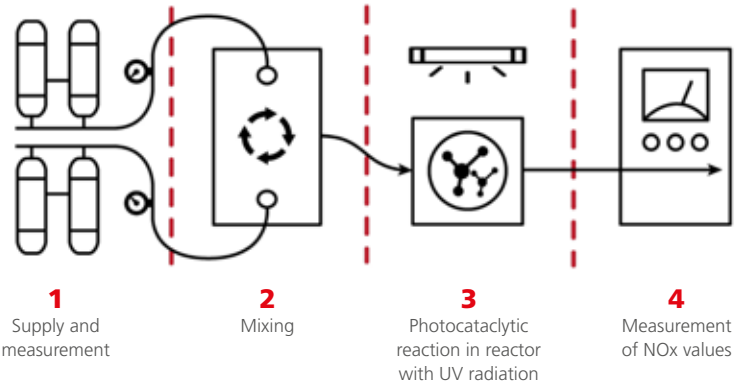
Below, we will go into more detail in a laboratory study that measures the TiO2 purified air concentrations according to predetermined parameters.



### 4.3.2 CONCENTRATION OF AIR PURIFICATION

The photocatalytic effect of IKO carrara has been tested by the Road Construction Research Centre (OCW) in accordance with ISO 22197-1 "Test method for air-purification performance of semiconducting photocatalytic materials - Part 1: Removal of nitric oxide".

Using the diagram below, we illustrate the test set-up according to the above-mentioned ISO standard (ISO 22197-1, 2007):



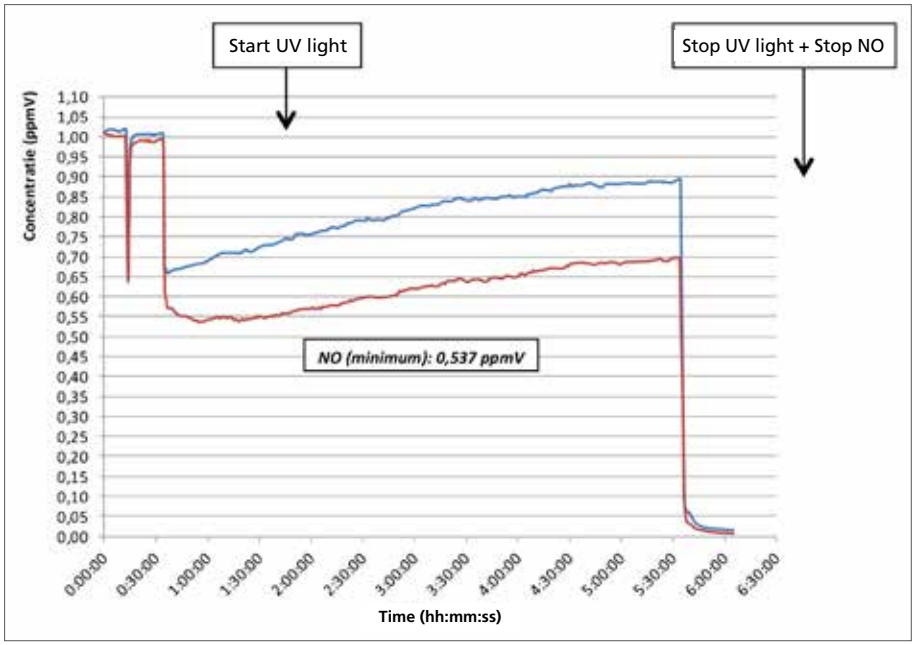
**1** Supply and measurement

**2** Mixing

**3** Photocataclytic reaction in reactor with UV radiation

**4** Measurement of NOx values

This test set-up makes it possible to measure the effective air-purifying properties of IKO carrara roofing membrane. Over a period of 6 hours, the evolution of nitrogen and nitric oxide concentrations is measured, before and after contact with the $TiO_2$ on the roofing membrane. The curve below shows the evolution of the measured concentrations during the test period.




NOx (ppmV)
No (ppmV)

We can observe that the measured nitrogen monoxide and nitric oxide concentrations in the outgoing air decrease drastically as soon as the UV radiation on the roofing membrane irradiates. The test was performed at air humidity of 50% and an ambient temperature between 22.5 and 23.8°C. The measured NO concentration in the mixing vat is always 1 ppmV, after which the air is passed through the reactor with an air flow of 3 litres per minute.

Test results:

| | |
|---|---|
| Reduction NO | 37,5% |
| Reduction NOx | 20,1% |

The test results show that air layers that come into contact with IKO carrara contain 37.5% less nitrogen monoxide and 20.1% less nitric oxide. This results in a significant improvement of air quality (OCW, 2012).

### 4.3.3 AIR-PURIFYING PROPERTIES

A number of studies have been carried out to gain insight into the air-purifying properties of $TiO_2$. However, the results of these studies vary widely. Reductions of 60 to 90 mg/m² per day, 54 mg/m² per day, 12,5 mg/m² per day and 23 to 27 mg/m² per day have all been recorded. The different results can be explained by the parameters applied (light intensity, NOx concentration, airflow, type $TiO_2$, etc.) during these laboratory experiments. At any rate, all of the studies confirm that $TiO_2$ converts any nitric oxides present into harmless nitrates.

In the following sections, we calculate the effective air-purifying action of an IKO carrara roof in Belgium, based on the above-mentioned parameters.
The calculation is based on samples tested in practice in accordance with the ISO 22197-1 standard and current weather conditions in accordance with the published annual reports of the Belgian RMI (Royal Meteorological Institute).

*Current emissions from the EURO 6 vehicle fleet:*

| | |
|---|---|
| EURO 6 standard max. NOx emissions | 0.08 g/km (Hooftman et al., 2018) |

*Average distance travelled by Belgian passenger cars:*

| | |
|---|---|
| Average annual distance travelled: | 18,721 km per vehicle<br>(FPS Mobility and Transport, 2017) |

*Average annual emissions per vehicle:*

| | |
|---|---|
| EURO 6 standard max. NOx emissions | 1497.68 g per vehicle per year (0.08 g/km) |

*Average air purification according to surface:*

| | |
|---|---|
| Average air purification NOx<br>(Verhovsek, 2013) | 0.004 g/m²/hour (> 0.05 g/m² per day) |
| Average hours of sun per year based on the annual average for 2015 - 2016 - 2017<br>(RMI, 2018) | 1,621.58 hours |
| NOx degradation per m² per year<br>Annual air purification per 1.000 m² | 6.49 g<br>6,49 kg NOx (=1.932,92 kg $CO_2$ eq.)<br>= 4,33 passenger cars per year |
| **Required surface to neutralise the emissions of one EURO 6 vehicle** | **230,77 m²** |

The above values are minimum values under the indicated conditions. The effective air purification per m² is even higher since NOx breakdown also occurs during overcast periods.

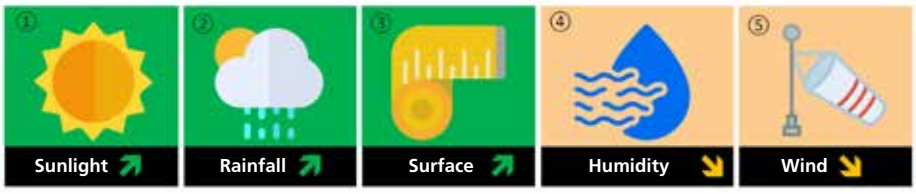
**We can therefore conclude that a Carrara roof of 500 m² can neutralise the average emissions of 2 to 3 passenger cars.**

### 4.3.4 APPLICATION AND EFFICIENCY

Over the past decade, air-purifying materials have gained in popularity in various branches of the construction industry. The Belgian Road Construction Research Centre (OCW) indicates that road surfaces with air-purifying properties are increasingly being used.

According to the OCW, laboratory results show that the use of such innovative building materials makes a tangible contribution to breaking down air pollution. However, the research does emphasise that the air-purifying properties are only retained if regularly purified by rainwater (Beeldens, 2014).

We discuss below the factors which determine the efficiency of titanium dioxide:




1. Sunlight: UV radiation is necessary as a catalyst for the air-purifying action of titanium dioxide
2. Rainfall: Periodic rainfall is essential to keep the surface clean. Thanks to the rain, the roof covering will be regularly purified
3. Surface: the larger the contact surface of the titanium dioxide, the more efficient the action
4. Humidity: The air-purifying action of titanium dioxide decreases with higher relative humidity (RH, %). Research has shown that water molecules in the air create a barrier between air pollution and roof surfaces with titanium dioxide
5. Wind: The lower the wind speed, the better. That way, there is longer contact with the polluted air, and the air will therefore be purified more efficiently

# 5. IKO CARRARA ROOF SYSTEMS
## OFFER THE BEST PROTECTION AGAINST BURNING BRAND

### 5.1 PROPERTIES

IKO carrara protects buildings against burning brand, thanks to the high-performance graphite technology on the inlay.

### 5.2 BENEFITS

1. IKO carrara roof systems offer extensive conceptual freedom thanks to comprehensive testing and excellent test results.

   IKO carrara roof systems can be applied to all types of buildings, thanks to their proven resistance to burning brand on various roof floors and insulation types.

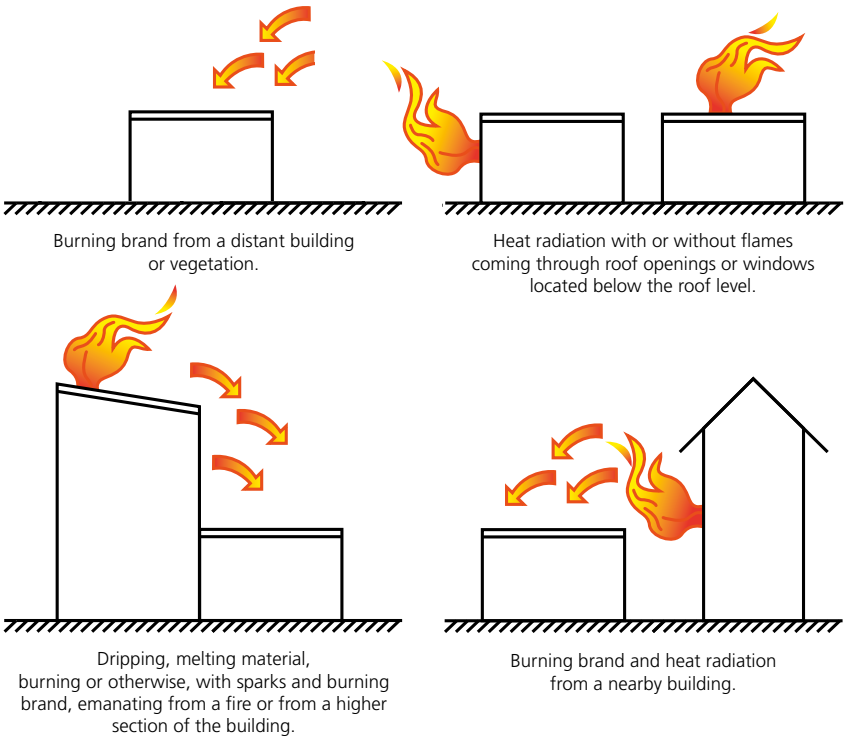
2. Protection of household contents, people and emergency services against burning brand.

   IKO carrara roof systems offer the best protection against an external fire, giving occupants and the emergency services the time they need to evacuate safely.

### 5.3 EXPLANATION

**Resistance to burning brand**

A fire can have both an internal and external cause. Especially in the event of a fire caused externally, the roof covering can be used to provide the desired protection or delay against the spread of a fire within well-designed specifications. This protection is referred to as resistance to external fire.

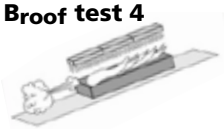
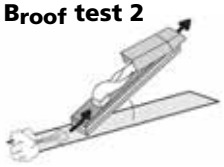
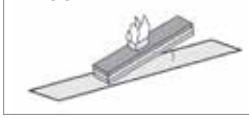


Burning brand from a distant building or vegetation.

Heat radiation with or without flames coming through roof openings or windows located below the roof level.

Dripping, melting material, burning or otherwise, with sparks and burning brand, emanating from a fire or from a higher section of the building.

Burning brand and heat radiation from a nearby building.

| | |
|---|---|
| **Secondary low smoke formation** | ▪ low smoke formation<br>▪ no toxic gases<br>▪ halogen-free<br>▪ limited burning droplets<br>▪ controled heat radiation |
| **Broof test 4**  | ▪ heat radiation over the entire surface<br>▪ wind |
| **Broof test 3**  | ▪ heat radiation<br>▪ wind<br>▪ contact met vuur |
| **Broof test 2**  | ▪ wind<br>▪ contact with fire |
| **Broof test 1**  | ▪ contact with fire<br>Traditional modified APP/SBS roofing membranes. |

## Test methods

European legislation provides for 4 different test methods. The 4 tests start from the principle of simulating the real danger of burning brand as accurately as possible. That is why in all tests, the roof surface is brought into direct contact with fire using burning wooden blocks or wood wool. This involves verifying whether the roof covering will make the fire spread or, on the contrary, extinguish the fire within an acceptable period of time. The distinction between the four tests is determined by the addition, or not, of wind and heat. It goes without saying that a test with wind and heat is more representative of a real fire situation.

The IKO carrara membrane achieves Broof t1-t4 in various roof structures.

For further information, please consult the White Paper 'Fire safety on flat roofs'.

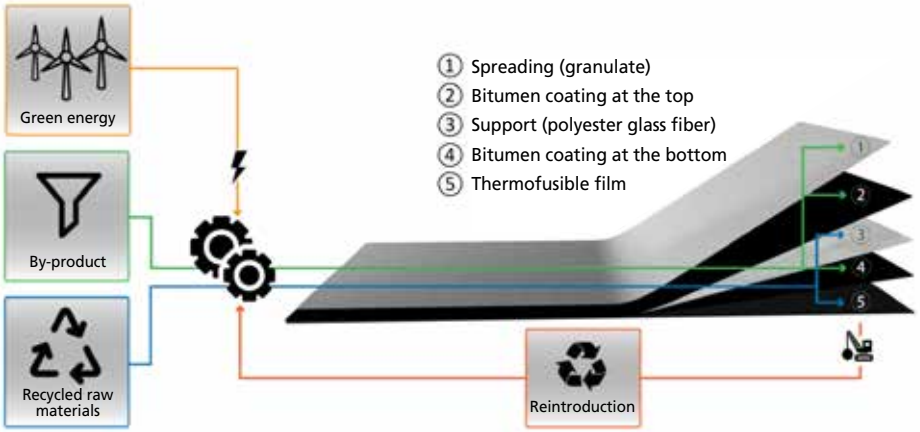
# 6. IKO CARRARA ROOF SYSTEMS
## ARE ECOLOGICAL AND RECYCLABLE

### 6.1 PROPERTIES
IKO carrara consists of a percentage of recycled raw materials and is completely recyclable. It is manufactured with 100% green power.

### 6.2 BENEFITS
1. A bituminous roof system with a small ecological footprint.
   An IKO carrara roofing membrane is produced using recycled raw materials and green power. Also in other phases of the life cycle.
2. Recyclable into various applications at the end of its life.
   An IKO carrara roofing membrane can be recycled after its utilisation phase, and reused in various building applications.

### 6.3 EXPLANATION
IKO carrara is produced for sustainable construction projects where longevity, recyclability and green manufacturing are essential. The various components of the product (reinforcement, bitumen coating, top finish, bottom finish) are manufactured with an emphasis on minimising the environmental impact.

IKO focuses on using the recyclate, reducing energy consumption, incorporating green electricity and minimising emissions.





### 6.3.1 RAW MATERIALS

The various elements of IKO carrara are produced using recycled raw materials and residual products:

- granulate is a residual product from quarries. The offcuts from the production process of slate and other types of stone are crushed into slate chippings or granulate.
- Bitumen is a by-product of popular fuels that are used every day in our society.
- the polyester inlay is produced with raw materials from the recycling of PET bottles and other packaging materials.

### 6.3.2 RECYCLING


Recycling is incorporated into the various stages of the production process. The factory is equipped with the necessary recycling machines that can process bituminous membranes into raw materials. These are reincorporated during the production of new roofing membranes. The addition of recycled materials during the production process is controlled in such a way that optimal quality is maintained. Recycling and quality go hand in hand.

**Please note:**

During the recycling of bituminous membranes, composition and separability is crucial, since a recyclable bitumen membrane:

- does not contain wood, stones, plastics such as PVC (except fine reinforcement fibres) or other organic residues
- does not contain adhesive insulation
- contains as few metals as possible

These membranes are cut into smaller pieces and then ground in a shredder.

### 6.3.3 ENERGY CONSUMPTION

IAs a manufacturer, IKO makes every effort to reduce its energy consumption to an absolute minimum during the production process.

That is why IKO is voluntarily affiliated to the EBO covenant (Energy Policy Agreement) of the Flemish government, as a manufacturer. This is a commitment to diligently manage and monitor energy consumption.

### 6.3.4 EMISSIONS

IKO consistently uses green power, and can substantiate this with audit documents. The site in Antwerp runs 100% on green power. The various sites are strategically and centrally located in order to keep the logistics process and the accompanying environmental impact as limited as possible.

IKO is affiliated with "Dak en Milieu", this foundation draws up environmental profiles of the primary roofing roles, at the European level. As such, IKO contributes to the transparency of the sector in terms of $CO_2$ emissions, and continuously optimises its business processes in the context of an environmentally responsible

business. The Dak & Milieu foundation was set up with the aim of ensuring environmentally responsible applications of sheet and shingle roof coverings. Dak & Milieu has been responding to developments and needs in the field of sustainable construction for almost 20 years.

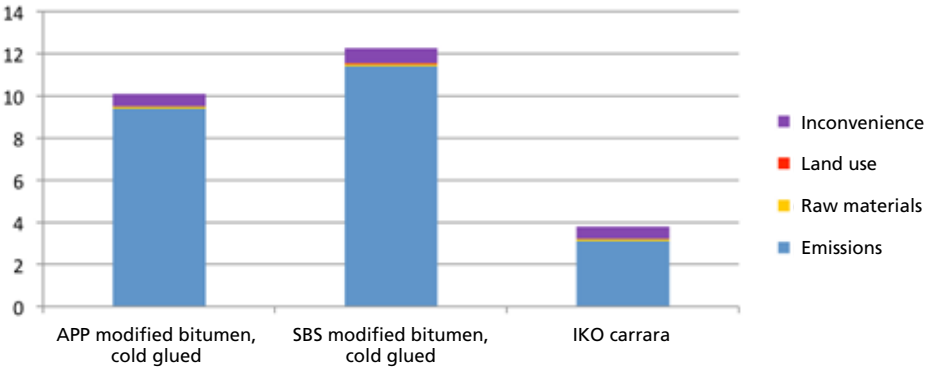
### 6.3.5 CERTIFICATION

**NIBE environmental classification**

To get a good idea of the environmental impact of a product, it is necessary to make a Life Cycle Analysis (LCA) to assess all of its life phases. NIBE (2017) expresses the effects in so-called shadow costs. The lower the shadow costs, the more sustainable the product and the tested fixing method is.

The best environmental products within a product group qualify for a DUBOkeur® certificate. Thanks to its strict scientific standards, DUBOkeur® is a good starting point for determining the environmental impact of a given product and the method used to install it.

**Shadow costs (in EUR /m²)**




The graph above shows the environmental impact of a traditional roofing membrane. NIBE found that the IKO carrara has a very low impact on the environment, as it scores more than 3x lower in terms of shadow costs in comparison with other SBS roofing membranes (instead of more than 12 EUR /m² shadow costs, the IKO carrara scores below 4 EUR /m²). That is why the IKO carrara has a DUBO certificate.

This certificate is available on request from your IKO advisor.

### 6.3.6 LEED / CRRC / ENERGY STAR / GREEN GLOBES RATING

The US Green Building Council has developed a LEED (Leadership in Energy and Environmental Design) standard for the development of high-performance and sustainable buildings. LEED provides up-to-date standards that can be applied voluntarily by construction partners.

The US GBC recommends using roofing membranes with an SRI value ≥ 78 for at least 75% of the total roof area of the project. With its SRI (Solar Reflectance Index) value of 79, the IKO carrara meets the LEED requirement for green buildings (US Green Building Council, 2009).

LLEED is the main, but certainly not the only pioneer of reflective roofing in America, the Cool Roof Rating Council (CRRC), ENERGY STAR, the US Green Globes system and the American Department of Energy also attach great importance to the reflective properties of flat roofs. Below you will find an overview of the various requirements that are recommended by these approved bodies.

| Rating and certification requirements for flat roofs | | IKO carara |
|---|---|---|
| Energy Star (Energy Star, 2018) | Initial Solar Reflectance ≥ 0.65<br>Solar Reflectance after 3 years ≥ 0.50 | ✓<br>✓ |
| CRRC | Solar Reflectance ≥ 0.70<br>Thermal Emittance ≥ 0.75 | ✓<br>✓ |
| LEED | SRI ≥ 78 | ✓ |
| Green Globes | SRI ≥ 78 | ✓ |

### 6.3.7 BRE ENVIRONMENTAL CLASS

The Building Research Establishment (the founder of BREEAM) has carried out a number of studies on the environmental impact of flat roofs.

These have shown that flat roofs fitted with an IKO carrara membrane achieve the highest environmental class. On a scale from E to A+, a roof structure with this bituminous roofing membrane scores an A+ classification:

A+ BRE
ENVIRONMENTAL GREEN GUIDE RATING

| | |
|---|---|
| IKO carrara roofing corresponds to the generic component/material 'polymer modified polyester reinforced bitumen roofing membranes with mineral finish' in the BRE Global Green Guide online generic specification(s) 'Flat roof: warm deck' (ref. 1212540006) which achieve(s) a summary rating of A+ within all tested building types (Industrial, Commercial, Domestic, Health, Retail, Education). | |
| Summary Rating, Climate Change, Water Extraction, Mineral Resource Extraction, Stratospheric Ozone Depletion, Human Toxicity, Ecotoxicity to Freshwater Nuclear Waste (higher level), Ecotoxicity to Land Waste Disposal, Eutrophication, Photochemical Ozone Creation, Acidification | A+ |
| Fosil Fuel Depletion | A |

### 6.3.8 ISO 14001 ENVIRONMENTAL MANAGEMENT SYSTEM

The ISO 14001 standard is an environmental management system that ensures optimum control and limitation of the environmental risks associated with business operations. The ISO 14001 standard is not a general obligation, although governments often require ISO 14001 certification in procurement contracts.

An environmental risk analysis forms the basis of this standard. This analysis identifies the potential environmental risks and assesses them in terms of all possible forms of pollution. Based on these environmental risks, the company draws up an environmental plan in which the necessary control measures are included.

The production of IKO roofing membranes and insulation is ISO 14001 certified, with certificate number BE010308-1 (Bureau Veritas, 2017).

This certificate is available on request from your IKO adviser.

ISO 14001
CERTIFIED ENVIRONMENTAL MANAGEMENT SYSTEM

# 7. IKO CARRARA ROOF SYSTEMS
## HAVE A PROVEN LIFESPAN OF MORE THAN 35 YEARS

### 7.1 PROPERTIES

IKO carrara has a stable and reliable bituminous elastomeric coating, strewn with granulate.

### 7.2 BENEFITS


1. Ease of renovation and maintenance.
   An IKO carrara top layer is easy to overlay, or adjust after installation.
2. Flexible elastomeric bitumen.
   IKO carrara consists of an SBS elastomeric bitumen, which is modified bitumen with flexible properties. This flexibility avoids unwanted permanent traces of handling during and after application.
3. Stable membrane.
   Extremely limited elongation and shrinkage, which guarantees adhesion at penetrations and upstands during the lifetime of the membrane. The membrane does not come loose from the roof structure and will not show any wrinkle formation, which also ensures good rain-water drainage.

### 7.3 EXPLANATION

Optimising the lifespan is only possible if correct and periodic roof maintenance is carried out. For more information, please consult the White Paper 'Periodic roof maintenance'. A bituminous roofing membrane is extremely easy to maintain.

Roof maintenance and renovation have a major impact on the utilisation phase of the roof. The greater the extended use of a flat roof, the lower the environmental impact. The utilisation phase has the lowest environmental impact in relation to the production phase, installation phase, and end-of-life phase.

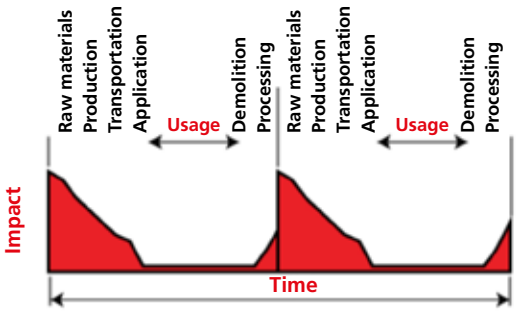



Fig. 1: "Al-te-vaak voorkomende" Levenscyclus Daksysteem (Hoff, 2009)

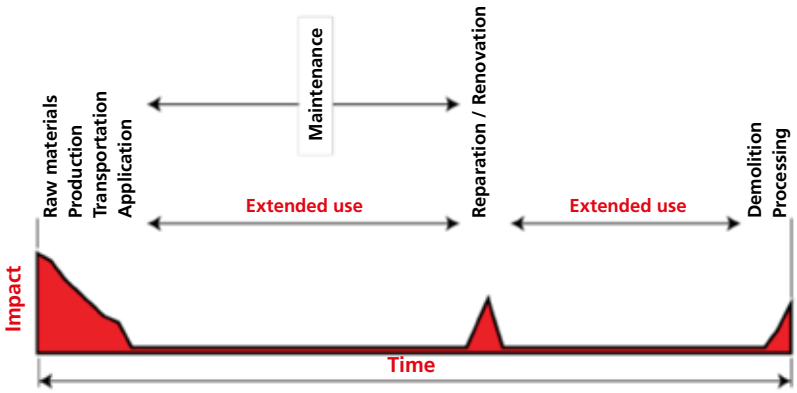



Fig. 2: Duurzame Levenscyclus Daksysteem (Hoff, 2009)

A study by BDA (Bureau Dakadvies) has shown that a two-layer bitumen roof has a lifespan of up to 35 years. A sustainable life cycle with bitumen can easily be achieved with effective roof maintenance and a one-off overlay. That way, the lifespan of the bituminous roof can be doubled.


The IKO carrara is ideal for an extended lifespan, since it is:

- extremely stable and not prone to shrinkage
- sufficiently thick, thereby preventing unwanted perforations
- not dependent on an external binding agent to bond to overlaps and to achieve a substrate
- a membrane with a proven lifespan in practice
- ideal for renovation and adaptation:
  - a bituminous membrane can be easily overlaid without the need for an additional ballast layer or mechanical attachment.
  - a roof that is adapted during its utilisation phase (e.g. new roof penetration) can be made perfectly waterproof with optimal adhesion.

# 8. IKO CARRARA ROOF SYSTEMS
## ARE SUITABLE FOR REUSING RAINWATER

### 8.1 PROPERTIES
IIKO carrara consists of an SBS bitumen coating which is suitable for greywater recovery.

### 8.2 BENEFITS
1. No impact on the pH level of rainwater run-off.
   The rainwater run-off from an IKO carrara roof has the same acidity as the rainwater run-off from a tiled roof. No acidification occurs.
2. No additional discolouration of the rainwater run-off.
   The IKO carrara has a mineral finish. This ensures that rainwater run-off during the utilisation phase is not subject to discolouration.

### 8.3 EXPLANATION
In the context of reusing rainwater, we discuss below the impact of IKO bituminous membranes on rainwater quality.

#### 8.3.1 ACID RAIN
The IKO research department carried out a pH laboratory test to analyse the acidity of rainwater run-off. In monthly intervals during 6 months, the collected samples were analysed. The results show that the IKO carrara roofing membrane has no influence on the acidity of rainwater run-off (IKO, 2015). This report is available on request.

#### 8.3.2 RAINWATER RECOVERY
Weather conditions are becoming more and more extreme. We are increasingly confronted with longer periods of drought, but also with more intense rain showers. This trend has resulted in an increasing need for sufficient rainwater buffer that can be used to tide over drier periods. Rainwater recovery on flat roofs is indispensable in this context. Every IKO bituminous top layer with a mineralised finish is suitable for greywater recovery. In this regard, we refer to documents from the BBRI (2013) and the Tauw (2009) which are available on request from your IKO advisor.
For further information, please consult the White Paper 'Rainwater recovery'.

# 9. IKO CARRARA ROOF SYSTEMS
## CAN BE USED FLEXIBLY

### 9.1 PROPERTIES
IIKO carrara is available with various finishes at the underside and overlap.

### 9.2 BENEFITS
1. IKO carrara can be used on new roofs, and for roof renovations.
   The roofing membrane can be used both in a new roof structure and in a roof renovation with a renovation layer that can be mechanically attached, or partially welded.
2. IKO carrara roof systems are available with both single-layer and double-layer membranes.
   IKO carrara roofing membranes can be used as single or double layers, for economic, ecological or technical reasons.
3. IKO carrara can be applied on various substrates with various fixing options.
   IKO carrara roofing membranes have been tested for use on various insulation types (PIR/MW/CG/EPS) and various roof floor types (concrete, wood, steel, fibre cement, renovation).

### 9.3 EXPLANATION
Below you will find an overview of the various membrane types, their product properties and the corresponding possible fixing method.

| Roof structure | Membrane system | Fixing method top layer | Thickness/ Weight | Broof | Name |
|---|---|---|---|---|---|
| New roof structure | Multi-layer | Flame welding | 4 mm | T4 | IKO carrara |
| | | | 5 mm | T3 | IKO carrara G |
| | Single-layer | Flame welding | 4 mm | T3 | IKO carrara Quadra |
| | | Mechanical | 5,5 kg/m² | T2 | IKO carrara Tecno SN |
| Renovation existing roof build-up | Single layer/Multi-layer | Flame welding | 4 mm | T3 | IKO carrara Quadra |
| | Single layer/Multi-layer | Mechanical | 5,5 kg/m² | T2 | IKO carrara Tecno SN |

| Fixing method | Membrane system | Thickness/Weight | Broof | Name |
|---|---|---|---|---|
| Flame welding | Multi-layer | 4 mm | T4 | IKO carrara |
| | | 5 mm | T3 | IKO carrara G |
| | Single layer/Multi-layer | 4 mm | T3 | IKO carrara Quadra |
| Mechanical fixing | Single layer/Multi-layer | 5,5 kg/m² | T3 | IKO carrara Tecno SN |

# 10. IKO CARRARA ROOF SYSTEMS
## ARE TRIED AND TESTED

### 10.1 PROPERTIES
IKO carrara has superior technical properties that have been proven at both product and system level.

### 10.2 BENEFITS
1. Transparent system applications with technical approval.
   The IKO carrara membrane has various technical approvals indicating the possible insulation types and underlays.
2. Good compatibility with a variety of roof layers.
   IKO carrara is part of a roof system. Since all layers in this system are produced by a single manufacturer, they have been subjected to tests, in various combinations, for wind stability, fire safety, chemical compatibility and stability.

### 10.3 EXPLANATION
The IKO carrara membrane has been tested according to various standards in several countries, for its product and system properties. We list the most important tests below.

**ATG TECHNICAL APPROVAL**
(ATG 2996 / ATG 2323)
IKO carrara was subject to product certification according to the applicable ATG certification regulations.
This certification procedure includes continuous production control by the manufacturer, supplemented by regular external supervision by the certification body assigned by the non-profit organisation UBAtc.

**SINTEF TECHNICAL APPROVAL**
(TA 20385)
IKO carrara was also tested in a structure with a single-layer membrane. IKO carrara Tecno complies with the Norwegian building regulations in accordance with the properties, areas of application and conditions tested in this certificate.

**BDA APPROVAL FOR ROOF SYSTEMS**
(BAR 16-047/02/A)
The IKO carrara is part of the IKO "Eco Roof Concept", an ecological and sustainable roof system that has been fully tested by Bureau Dakadvies (BDA Expert Centre, 2016).

**KOMO PRODUCT CERTIFICATE**
(CTG 500)
IKO carrara was tested on the application conditions as laid down in the KOMO certificate ATT-500/1 for roofing systems with SBS membranes. The environmental hygienic specifications as laid down in BRL 9327 are also met.

## FI TECHNICAL APPROVAL

11316-15 (TL)

IKO carrara was also tested for compliance with Finnish building product standards. The membrane was tested in various multi-layer structures in terms of product properties, system properties and fire safety.

## TA TECHNICAL APPROVAL

(TA 0360/97)

IKO carrara has Swedish certification for use in a roof system with a mechanically attached single layer membrane. The membrane was tested for compatibility with various types of substrates and roof functions.

## IAB TECHNICAL APPROVAL

(IAB 08/0316)

The IKO carrara roof system was also tested in Ireland for applications in various multi-layer roof structures. This certification gives a positive opinion in terms of fire behaviour, compatibility, wind resistance, durability, lifespan and recyclability.

## BEAL CERTIFICATE

(BEAL)

The BEAL certification from New Zealand includes an audit of the production quality management system in which the management of all risks related to production, packaging, labelling and storage of the roofing membranes is analysed.

You can request the desired certificates from your IKO adviser.

# 11. IKO CARRARA ROOF SYSTEMS

## OFFER THE MOST PEACE OF MIND THANKS TO ITS ALL-IN WATERPROOF GUARANTEE

### 11.1 PROPERTIES

IKO carrara can be applied with an insured waterproof guarantee that covers the product, the concept and the implementation.

### 11.2 BENEFITS

1. Free of charge.
   This insured guarantee is offered free of charge on IKO carrara roof systems that are installed in conformity.
2. The manufacturer will coordinate the smooth processing of the guarantee.
   IKO is the central point of contact if the guarantee is invoked. This ensures all parties are assured of a smooth and correct processing when they wish to invoke the guarantee.
3. The manufacturer provides project support in the design and implementation phase.
   IKO gives both the necessary support to the architect for the design, as well as to the roofer during the implementation of the works.
4. The new value of the roof remains insured for 10 years.
   The insured value is not depreciated on an annual basis, the invoiced value remains applicable during the term of the insured guarantee.
5. In the event of bankruptcy of the policyholder, the guarantee will continue to apply.
   The insured guarantee remains guaranteed for the client if the roofer and/or manufacturer have ceased their activities.
6. Both the products, installation and any consequential damage are covered.
   The IKO insured guarantee covers much more than just product faults.

### 11.3 EXPLANATION

This insurance guarantees, for a period of 10 years, compensation if the roofing membrane fails due to a manufacturing defect in the membrane products and/or a construction and/or concept defect in the roof membrane system.


The compensation includes the removal, re-delivery and re-installation of the faulty membrane products free of charge in the event of one of the above-mentioned defects, as well as compensation for physical, material and/or immaterial consequential damage in the event of membrane defects as a result of a product fault.

The insurance policy has been taken out with an officially recognised insurance company and is backed up by a "Guarantee certificate" with a unique reference number.

More information about the insured guarantee can be found in the White Paper 'Insured guarantees for flat roofs'.

# 12. APPLICATION CRITERIA

## DOES THE ROOF GET ENOUGH SUNLIGHT IN SUNNY PERIODS?

An IKO carrara roof system comes into its own on roofs that receive sufficient sunlight. Among other things, UV light is necessary for the air-purifying action and the reflection values of the membrane.

## DOES THE ROOF FLOOR HAVE SUFFICIENT SLOPE?

The BBRI recommends a gradient of 2% on flat roofs, to ensure good drainage. This increases the lifespan of the membrane and guarantees the functional performance of an IKO carrara roof system. Structural water stagnation should be avoided at all times.

## DOES THE ROOF RECEIVE PERIODIC MAINTENANCE?

Like traditional roof systems, an IKO carrara roof system requires periodic maintenance. This periodic maintenance is not only essential to keep your roof system in good condition, but is also a requirement as part of the insured guarantee. During periodic maintenance, the use of "IKO proStop Groene Aanslag" is recommended to remove and prevent any fouling.

## IS IT A VISIBLE ROOF?

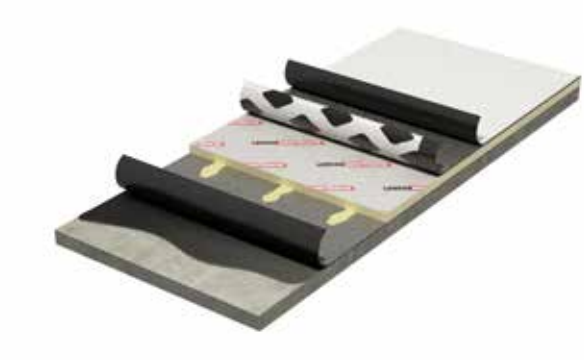
An IKO carrara roof system is primarily a functional roof system. It goes without saying that fouling is more visible on a white-coloured roof covering. Even during longer periods without sunlight (e.g. winter periods) the white colour can fade. After a brief sunny period, titanium dioxide will regain its white colour under the influence of sunlight.

## IS IT A COLD ROOF?

Cold roofs have become obsolete, as they are highly prone to internal condensation. A cold roof needs a considerable amount of summer heat to dry out, which is why using a thermally-insulating IKO carrara roof system on cold roofs is not recommended. In both newbuild construction and renovation applications, it is best to opt for a warm roof concept in which the vapour barrier and the insulation are applied on top of the supporting structure, instead of underneath or in between.

# 13. CARRARA SYSTEM SOLUTIONS

→ NEWBUILD
→ CONCRETE
→ GLUED SYSTEM



**TOP LAYER**
IKO carrara

**FIXING TOP LAYER**
Full adhesion by flame welding

**UNDERLAY**
IKO base quadra T/SA
IKO base quadra F/SA
IKO base quadra T/F at t° < 5°C

**FIXING UNDERLAY**
Remove the release liner + apply
Partially welded at t° < 5°C

**INSULATION**
IKO enertherm ALU
IKO enertherm BM at t° < 5°C,
with bituminous side facing up

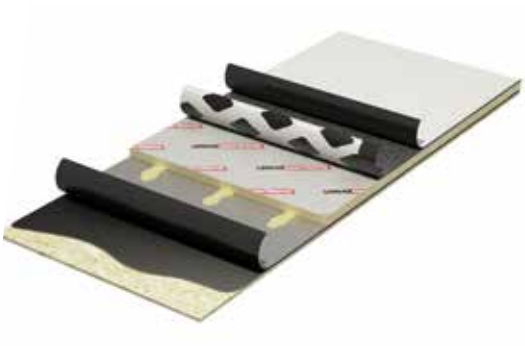
**FIXING INSULATION**
Partially glued with IKO pro PU-glue

**VAPOUR BARRIER**
IKO shield ALU 3 T/F
IKO shield ALU 4 T/F

**FIXING VAPOUR BARRIER**
Full adhesion by flame welding

**SUBSTRATE**
Concrete + IKO pro quickprimer
or IKO pro ECO primer

→ NEWBUILD
→ STEELDECK / WOOD
→ GLUED SYSTEM



**TOP LAYER**
IKO carrara

**FIXING TOP LAYER**
Full adhesion by flame welding

**UNDERLAY**
IKO base quadra T/SA
IKO base quadra F/SA
IKO base quadra T/F at t° < 5°C

**FIXING UNDERLAY**
Remove the release liner + apply
Partially welded at t° < 5°C

**INSULATION**
IKO enertherm ALU
IKO enertherm BM at t° < 5°C,
with bituminous side facing up

**FIXING INSULATION**
Partially glued with IKO pro PU-glue

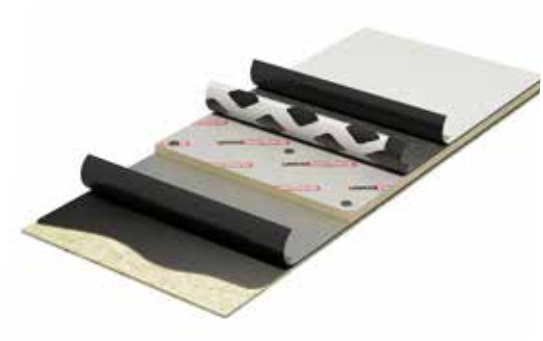
**VAPOUR BARRIER**
IKO shield PRO ALU/SA

**FIXING VAPOUR BARRIER**
Remove the release liner + apply

**SUBSTRATE**
Wood + IKO pro SA primer

These roof structures are a schematic representation, not exhaustive. Always consult your IKO specialist.

→ NEWBUILD
→ STEELDECK / WOOD
→ MECHANICALLY ATTACHED INSULATION



**TOP LAYER**
IKO carrara

**FIXING TOP LAYER**
Full adhesion by flame welding

**UNDERLAY**
IKO base quadra T/SA
IKO base quadra F/SA
IKO base quadra T/F at t° < 5°C

**FIXING UNDERLAY**
Remove the release liner + apply
Partially welded at t° < 5°C

**INSULATION**
IKO enertherm ALU
IKO enertherm BM at t° < 5°C,
with bituminous side facing up

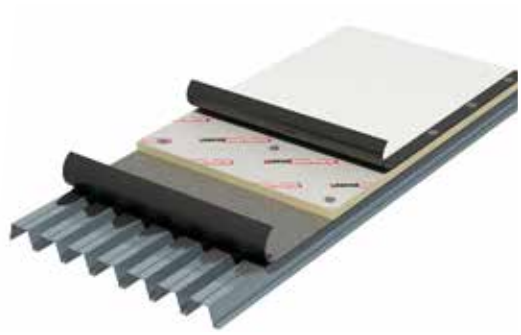
**FIXING INSULATION**
Mechanically attached with IKO fix EDS-S,
round plates

**VAPOUR BARRIER**
IKO base stick T/SA

**FIXING VAPOUR BARRIER**
Remove the release liner + apply

**SUBSTRATE**
Wood + IKO pro SA primer

→ NEWBUILD / SINGLE LAYER
→ STEELDECK
→ MECHANICALLY ATTACHED INSULATION



**TOP LAYER**
IKO carrara tecno SN

**FIXING TOP LAYER**
Mechanically attached along the seams
with IKO fix EDS-S

**UNDERLAY**
Not applicable

**FIXING UNDERLAY**
Not applicable

**INSULATION**
IKO enertherm ALU

**FIXING INSULATION**
Mechanically attached with IKO fix EDS-S,
round plates

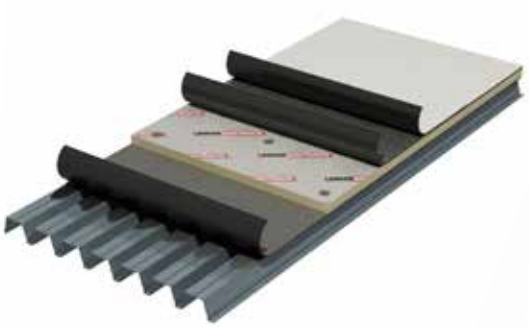
**VAPOUR BARRIER**
IKO base stick T/SA

**FIXING VAPOUR BARRIER**
Remove the release liner + apply

**SUBSTRATE**
Steeldeck + IKO pro SA primer

These roof structures are a schematic representation, not exhaustive. Always consult your IKO specialist.

→ NEWBUILD
→ STEELDECK / WOOD
→ MECH. ATTACHED INSUL. & UNDERLAY



**TOP LAYER**
IKO carrara

**FIXING TOP LAYER**
Full adhesion by flame welding

**UNDERLAY**
IKO base P3
IKO base Turbo

**FIXING UNDERLAY**
Mechanically attached

**INSULATION**
IKO enertherm ALU

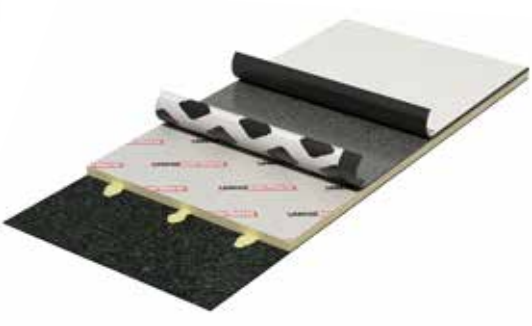
**FIXING INSULATION**
Mechanically attached with IKO fix EDS-S, round plates

**VAPOUR BARRIER**
IKO base Stick T/SA

**FIXING VAPOUR BARRIER**
Remove the release liner + apply

**SUBSTRATE**
Steeldeck + IKO pro SA primer

→ RENOVATION
→ WITH INSULATION
→ GLUED SYSTEM



**TOP LAYER**
IKO carrara

**FIXING TOP LAYER**
Full adhesion by flame welding

**UNDERLAY**
IKO base quadra T/SA
IKO base quadra F/SA
IKO base quadra T/F at t° < 5°C

**FIXING UNDERLAY**
Remove the release liner + apply
Partially welded at t° < 5°C

**INSULATION**
IKO enertherm ALU
IKO enertherm BM at t° < 5°C, with bituminous side facing up

**FIXING INSULATION**
Partially glued with IKO pro PU-glue

**VAPOUR BARRIER**
Old roof covering

**FIXING VAPOUR BARRIER**
Check for wind stability if glued

**SUBSTRATE**
Old roof covering

These roof structures are a schematic representation, not exhaustive. Always consult your IKO specialist.

→ RENOVATION
→ WITHOUT INSULATION
→ PARTIAL FLAME WELDED SYSTEM

**TOP LAYER**
IKO carrara quadra

**FIXING TOP LAYER**
Partieel gevlamlast

**UNDERLAY**
Not applicable

**FIXING UNDERLAY**
Not applicable

**INSULATION**
Not applicable

**FIXING INSULATION**
Not applicable

**VAPOUR BARRIER**
Not applicable

**FIXING VAPOUR BARRIER**
Verifying old bitumen roof covering on wind stability

**SUBSTRATE**
Old bitumen roof covering +
IKO pro quickprimer or ECO primer

## TOP FINISHING:

| | |
|---|---|
| **GRW** | → white granulate |
| **GRB** | → black granulate |
| **T** | → tallow/sand |
| **AD** | → dark slate chippings |
| **AR** | → light slate chippings |
| **AW** | → white slate chippings |
| **F** | → full flat sacrificial film |
| **ALU** | → aluminium foil |

## REINFORCEMENT:

| | |
|---|---|
| **V** | → lass-fibre reinforcement |
| **P** | → polyester reinforcement |
| **ALU** | → aluminium reinforcement |

## UNDERNEATH FINISHING

| | |
|---|---|
| **F** | → full flat sacrificial film |
| **QUADRA** | → diamond tread |
| **TURBO** | → cleat pattern |
| **MMP** | → macroperforated polyethylene sacrificial film |
| **SA** | → siliconised, white release liner, self-adhesive |
| **T** | → tallow/sand |
| **FL** | → naked polyester fleece |

## ROOF STRUCTURE

Top layer
Underlay
Insulation layer
Vapour barrier

These roof structures are a schematic representation, not exhaustive. Always consult your IKO specialist.

## SOURCE LIST


- Agroui, K., Hadj Arab, A., Pellegrino, M., Giovanni, F., Hadj Mahammad, I. (2011). Indoor and outdoor photovoltaic modules: performances based on thin films solar cells. Revue des Energies Renouvelables, Vol. 14 N°3, pp. 469 - 480.
- ASTM Standard E1980-11 (2001). Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces. Philadelphia: ASTM International.
- BDA Expert Centre (2016). BDA Agrément® BAR 16-047/02/A. Gorinchem: Kiwa BDA Expert Centre Building Envelope (ECBE)
- Beeldens, A., Boonen, E. (2014). Fotokatalyse: de luchtzuiverende weg. Brussels: OCW.
- Blasnik, M. (2004). Impact Evaluation of the Energy Coordinating Agency of Philadelphia's Cool Homes Pilot Project. Boston: Blasnik & Associates.
- BOMA - Building Owners Managers Association (1998). Office Tenant Moves and Changes. Washington: Building Owners and Managers Association.
- BRE (2017). Green Guide to Specification. https://www.bre.co.uk/greenguide/(consulted 3 May 2017).
- Bureau Veritas (2017). Certificate of approval Standard ISO 14001:2004: BE010308-1. Antwerp: Bureau Veritas Certification.
- CEC - California Energy Commission (2008). Evaluation of titanium dioxide as a photocatalyst for removing air pollutants. California: University of California Dpt. of Energy.
- Cool Roof Rating Council - CRRC (2017). Rated products directory. http://www.coolroofs.org (consulted 3 October 2017).
- Ecoscore (2018). Hoe berekenen we een Ecoscore als bepaalde data ontbreken? http://ecoscore.be/nl/info/ecoscore/missing-data
- Electropaedia (2017). Solar Power (Technology and Economics). http://www.mpoweruk.com/solar_power.htm (consulted 14 November 2017).
- Energy Star (2018). https://www.energystar.gov/products/building_products/roof_products/key_product_criteria (consulted 5 October 2017)
- EEA - European Environment Agency (2015). Climate change adaptation: Projected changes in annual mean temperature and annual precipitation. https://www.eea.europa.eu/data-and-maps/figures/projected-change-in-annual-mean/#enter-your-email-address-where-to-send-projected-changes-in-annu (consulted 3 March 2017)
- EEA – European Environment Agency (2017). Climate change adaptation: mean precipitation.. https://www.eea.europa.eu/data-and-maps/indicators/european-precipitation-2/assessment (consulted 5 April 2017)
- FPS Mobility and Transport (2017) Kilometres travelled by Belgian vehicles. Brussels: Directorate-General Sustainable Mobility and Railway policy.
- Hoff, J. L. (2009). The expanding role of the roof in a sustainable world. Presentation at CONSTRUCT 2009, Indianapolis, Indiana. Available online: http://www.ceirresearch.org
- Hooftman et al. (2018). A review of the European passenger car regulations - Real driving emissions vs local air quality. Renewable and Sustainable Energy Reviews, 86, pp. 6.


- IKO (2015). Opvolging (1 jaar) pH regenwater Polygum Carrara. Antwerp: IKO.
- ISO 22197-1 (2007). Test method for air purification performance of semiconducting photocatalytic materials - Part 1: Removal of nitric oxide. Switzerland: ISO - International Organisation for Standardization.
- Jafari Fesharaki, V., Majid Dehghani, J., Jafari Fesharaki (2011). The Effect of Temperature on Photovoltaic Cell Efficiency. Najaf Abad: Azad University.
- KIWA BDA: https://www.kiwabda.nl/
- RMI (2018). Karakteristieken van enkele klimatologische paramters. https://www.meteo.be/meteo/view/nl/360361-Parameters.html
- Brussels Environment (2007). Een nieuwe definitie van thermisch comfort: praktische handleiding voor de duurzame bouw en renovatie van kleine gebouwen. Brussels: Brussels Instituut voor Milieubeheer.
- Liddament, M.W. (1996). A Guide to Energy Efficient Ventilation. Coventry: Air Infiltration and Ventilation Centre.
- Mahmood, F., Majeed, H., Agha, H., Ali, S., Tatapudi, S., Curtis, T., TamizhMani, G. (2017). Temperature coefficient of power (Pmax) of field aged PV modules: impact on performance ratio and degradation rate determinations. Washington: SPIE.
- NIBE - Nederlands Instituut voor Bouwbiologie en Ecologie (2017). Handleiding voor gebruik van milieu-classificaties. https://www.nibe.info/nl/handleiding_voor_gebruik (consulted on 4 May 2017).
- NIBE - Nederlands Instituut voor Bouwbiologie en Ecologie (2015). Classificatielabel dakbedekking platte daken. https://www.nibe.info/nl/members#group-229-105 (consulted on 25 August 2017)
- OCW - Road Construction Research Centre (2012). Beproevingsverslag RE-EP-009917-1/1719. Sterrebeek: BRRC.
- OMT - Optical Measurements & Testing Materials for Optical Technology Thin Film Design and Analysis (2015). Calculation Report: SRI (ASTM E1980) calculation based on measurement results from report REP-213031-01a and REP-211032-01. Eindhoven: OMT.
- Oseland, N. et al. (1999). Environmental Factors Affecting Office Worker Performance: A Review of Evidence. Technical Memorandum 24. London: The Chartered Institution of Build Services Engineers.
- Schweisheimer, W. (1962). Does Air Conditioning Increase Productivity? Heating and Ventilating Engineer, 669, pp. 419.
- Symoens, L. (2011). Invloed van stof en schaduw op de productiviteit van fotovoltaïsche installaties. Ghent: University of Ghent.
- Tauw (2009). Afstromend regenwater van bitumen daken. Amsterdam: Tauw.
- University of Melbourne (2011). Cool roofs: City of Melbourne Research Report. Melbourne: University of Melbourne.
- U.S. Green Building Council (2009). LEED: Heat island reduction. https://www.usgbc.org/credits/neighborhood-development-plan-neighborhood-development/v2009/gibc9 (read on 4 June 2017)
- U.S. Department of Energy (2002). Estimates Cooling and Heating Savings for Flat Roofs with Non-Black Surfaces. Oak Ridge: Oak Ridge National Laboratory.
- U.S. Department of Energy (2017). Cool roofs. https://www.energy.gov/energysaver/energy-efficient-home-design/cool-roofs (consulted on 23 March 2017).
- U.S. Environmental Protection Agency - EPA (2011). Reducing Urban Heat Islands: Compendium of Strategies. Washington: EPA.
- Verhovsek, D. (2013). Titanium dioxide as a photocatalyst for incorporation into building materials for air remediation. Celje: Cinkarna.
- VMM - Vlaamse Milieu Maatschappij (2017). Luchtkwaliteit: actuele meetresultaten. https://www.vmm.be/lucht/luchtkwaliteit (consulted on 5 April 2017).
- Wong, E. et al. (2014). Reducing Urban Heat Islands: Compendium of Strategies. Washington: Environmental Protection Agency.
- BBRI (WTCB) - Belgian Building Research Institute (Wetenschappelijk en Technisch Centrum voor het Bouwbedrijf) (2013). Recuperatie van regenwater van platte daken met bitumineuze afdichtingen. [document drawn up on 9/7/2013 with reference 510/57092/EMAH/NVDB]
- BBRI (WTCB) - Belgian Building Research Institute (Wetenschappelijk en Technisch Centrum voor het Bouwbedrijf) (2017). Het thermisch comfort in de zomer waarborgen. WTCB Contact, 56, p. 28


UNITED STATES OF AMERICA

# IKO CARRARA, THE SUSTAINABLE SOLUTION FOR FLAT ROOFS:


Better efficiency of technical installations on flat roofs.


Air purification of harmful substances.


Reducing heat radiation in buildings.


Reusing rainwater.


Protecting buildings against burning brand.


Recycling roofing membranes at end-of-life.


Easy to maintain and repair.


Long lifespan tested in practice.


Sturdy and shrink-resistant membranes.

ROOFING I WATERPROOOFING I INSULATION

**IKO nv** - d'Herbouvillekaai 80 - 2020 Antwerp - Belgium - +32 3 248 30 00 - be.iko.com



IKOnv / BR201811 / CARRARADOS / EN / 0001