Let's be transparent!

DIAMOND

THE WORLD'S MOST TRANSPARENT ENERGY SCREEN

Phormium

Supporting growers since 1977

INTRODUCTION

DIAMOND

DIAMOND, the new benchmark in transparent energy screens, is Phormium's answer to crop's insatiable desire for light.

DIAMOND combines unprecedented transparency for PAR light with the moisture transport and energy-saving properties of traditional transparent energy screens.

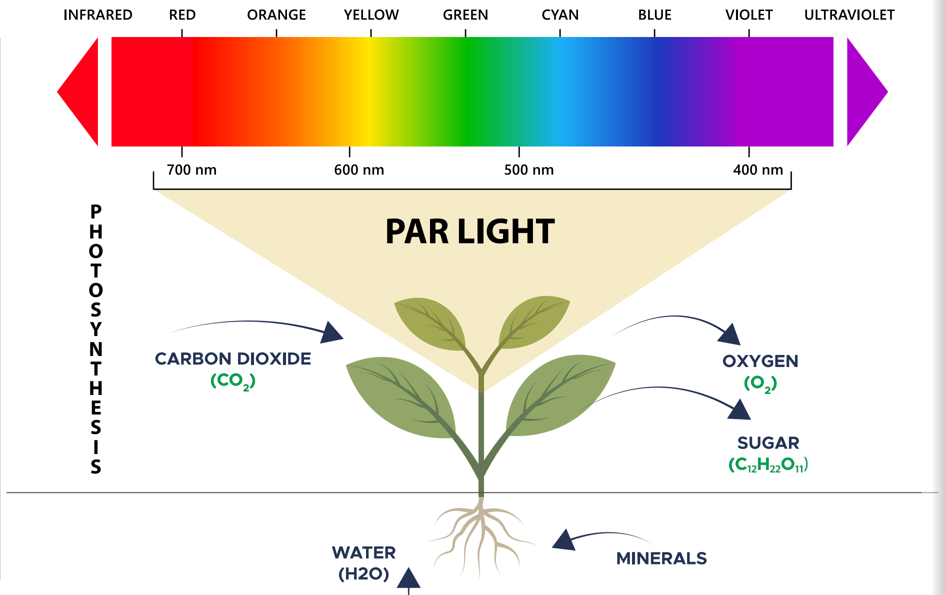
The **PAR shading rate** is one of the most important parameters of a transparent energy screen. This is hardly surprising, given that PAR is directly linked to crop yield.
For light-loving crops such as tomatoes, the rule of thumb is: 1% more light equals 1% more yield. Every photon counts—that's what it's all about. That's why screen manufacturers are pulling out all the stops to make energy screens increasingly more transparent.

PAR-SHADING

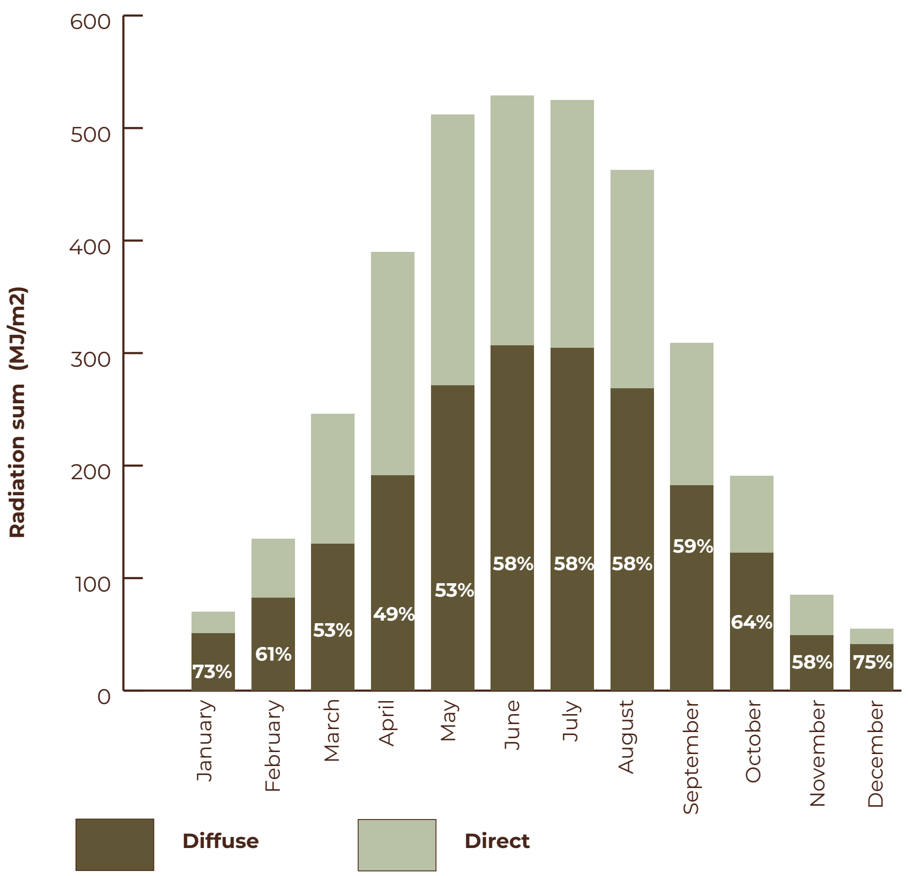
PAR (Eng: photosynthetically active radiation) **plays a particularly important role in the growth and development of crops**. Ranging from 400 nanometers (blue) to 700 nanometers (red), PAR light largely coincides with the light that is visible to the human eye. In addition to PAR, there are also UV (ultraviolet), FR (far red), and NIR (near infrared). These types of light also play a role in the greenhouse. However, this is beyond the scope of this whitepaper.

PAR light is necessary for photosynthesis and drives the growth of a crop.

Without PAR light, a crop cannot develop. During periods with limited light availability (e.g., in winter), the scarcity of PAR light often restricts crop development. Therefore, the more one can utilize the limited available amount of PAR light, the better.



PAR comes in various forms. The angle at which PAR light strikes a material (e.g., a screen) determines the character of the PAR light. A distinction is made between **diffuse PAR light** and **direct PAR light.**
We refer to diffuse PAR light when light strikes the screen from all angles simultaneously.
In direct light conditions, light enters at a specific angle.
Diffuse light conditions correspond to those beneath a heavily overcast sky.
Direct lighting conditions are found beneath a clear (cloudless) sky.



Graph 1: Proportion of direct and diffuse sunlight in the Netherlands, source: Kaskieswijzer WUR

Figure 1 shows the proportion of solar radiation that is diffuse versus direct in the Netherlands. From the graph can be deduced that, during the darkest months of the year, 60 to 70% of the light reaching the Earth's surface is diffuse.

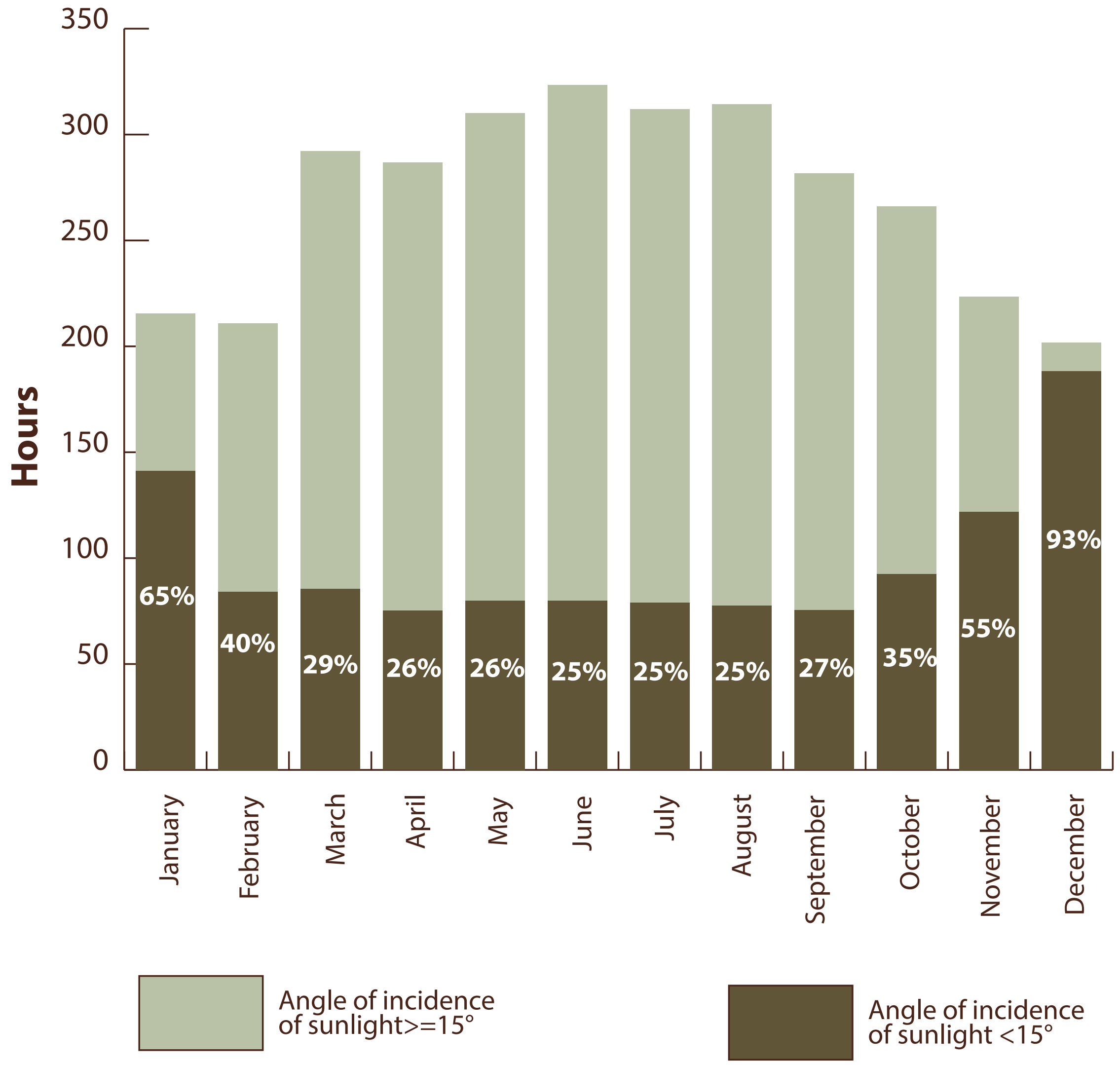
In **diffuse light conditions**, the position of the sun in the sky (which determines the angle of incidence of the light) is irrelevant. Because of the cloud cover, the light enters from all angles at the same time.

In **direct sunlight**, the position of the sun plays a very significant role. The sun may be close to the horizon or high in the sky.

The sun is always close to the horizon at sunrise and sunset. However, in areas that are relatively far from the equator, the sun remains low on the horizon for (much of) the day, even in winter.

In addition to graph 1, graph 2 illustrates the percentage of time during which the angle of incidence of the light is less than or greater than 15° relative to the horizon under direct light conditions in The Netherlands (averaged over the years 2017, 2018, and 2019). In other words, graph 2 provides more detail about the angle of incidence of the light for the part of the day during which the cloud cover created direct light conditions (graph 1).

Graph 2: Percentage of time during which the sun's angle of incidence is less than or greater than 15° relative to the horizon under direct light conditions in Zevenhuizen, the Netherlands, for the years 2017, 2018, and 2019 (average)



Graph 2 shows that, under direct light conditions, the sun is below 15° relative to the horizon for a significant portion of the time.

This is primarily the case in the months of November, December, and January, which is a consequence of the annual analemma of the sun. It is precisely during this time of year that transparent energy screens are used intensively in greenhouses.

The preceding paragraphs show that it is important to know the PAR shading rate of a screen under both diffuse and direct light conditions, and, in the latter case, at various angles of incidence. To this end, Wageningen University & Research (WUR) developed the NEN 2675 protocol. Graph 3 schematically illustrates how the PAR shading rate of a material is determined using a light source and an integrating sphere in accordance with the NEN 2675 protocol.

The PAR shading rate can be determined for direct light at a specific angle of incidence (e.g., 0° or 75°) and for diffuse light . It is important to note that the angle of incidence referred to in the NEN 2675 protocol is the angle between the light beam (emanating from the light source) and the line perpendicular to the screen. This angle is the complement of the angle between the light beam and the horizontal.

The horizontal axis corresponds to the screen or the horizon. Thus, an angle of 75° in the NEN 2675 protocol corresponds to an angle of 15° relative to the horizon.
This is illustrated in Figure 4.

Figure 3: Schematic representation of the NEN 2675 protocol of WUR

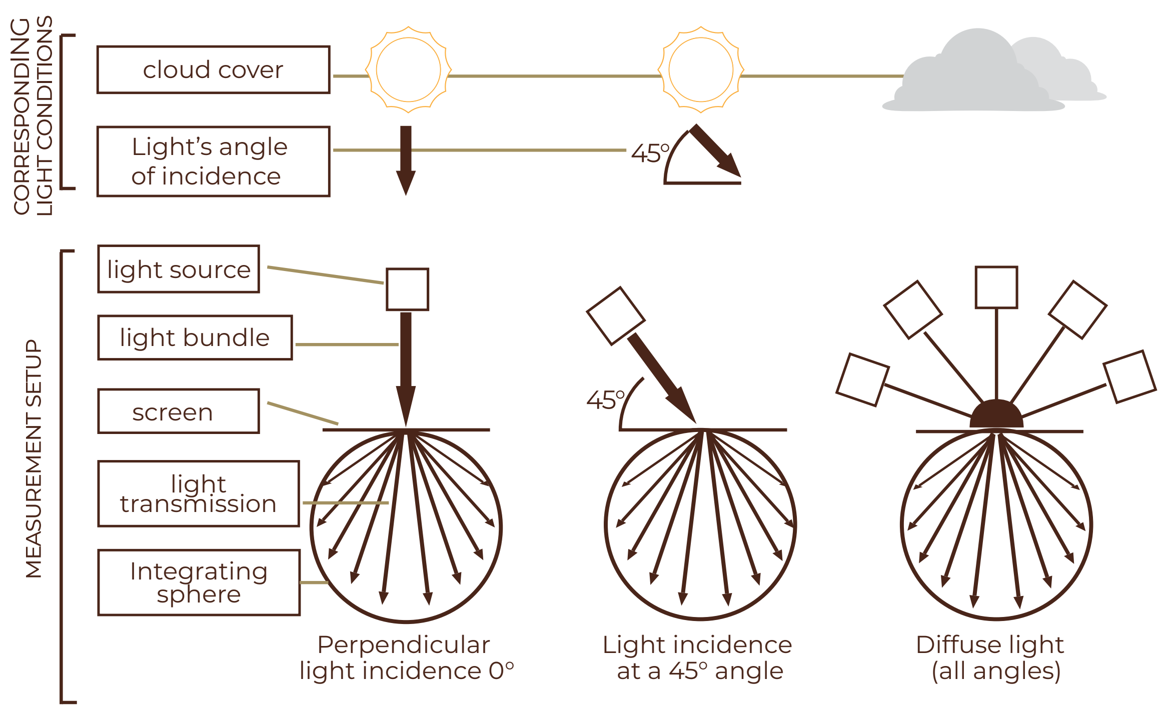
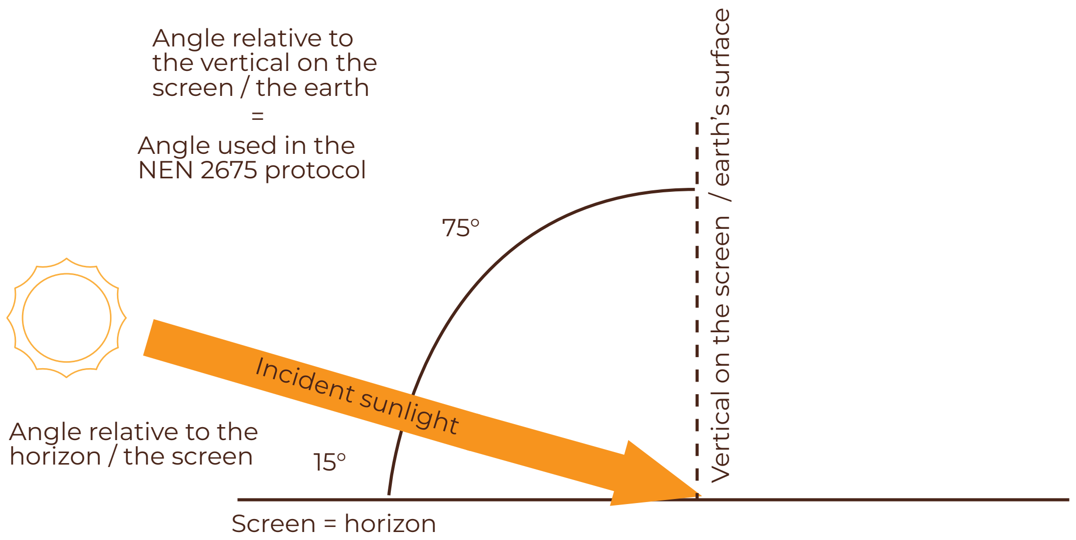


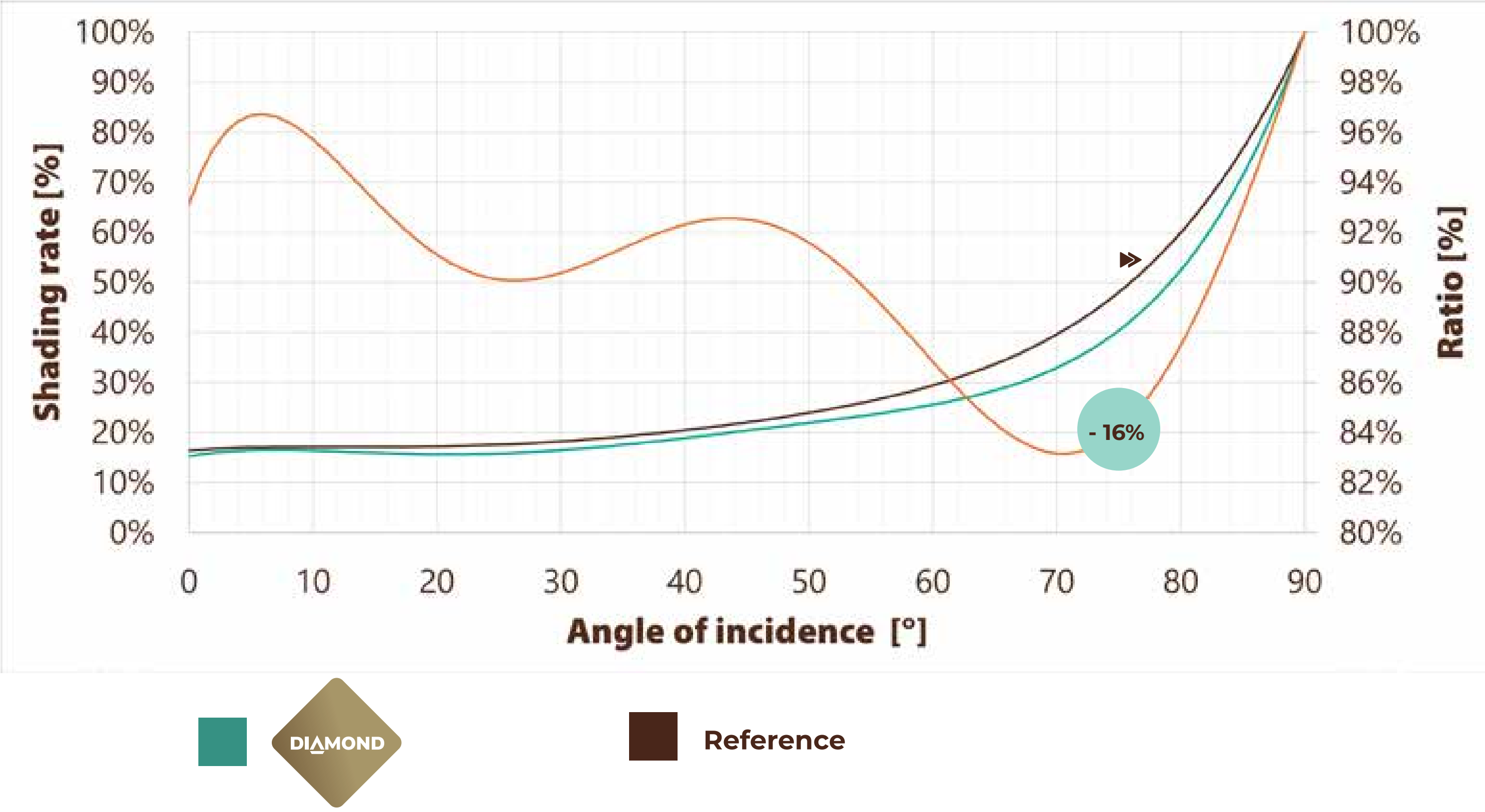
Figure 4: Illustration of the angle of incidence used in the NEN 2675 protocol



The shading rates of Phormium's **DIAMOND** are listed in Table 1. This table also includes the shading rates for the most frequently used alternative energy screen

The table shows that **DIAMOND** has a lower PAR shading rate under each of the above-mentioned light conditions. Note that under direct light conditions, as the sun gets lower (e.g., in winter) and the angle of incidence increases, the difference in the PAR shading rate between **DIAMOND** and the alternative also increases.
Table 1, which shows only a limited number of angles of incidence, is supplemented by Figure 5.

Graph 5: PAR shading rate of DIAMOND (green) and the most frequently used alternative (brown) for each angle of incidence according to NEN 2675. The orange line shows the ratio of the green curve to the brown curve.



The orange curve shows the ratio between the PAR shading rate of Diamond (green curve) and the most frequently used alternative energy screen (brown curve) for each angle of incidence. For example, at 75° (15° relative to the horizon), the shading rate of **DIAMOND** is 16% lower than that of the alternative.

DRYTEC™ TECHNOLOGY

DIAMOND incorporates DryTec™ technology. DryTec™ is a combination of moisture-transporting yarns and a surface treatment that provides DIAMOND with durable hydrophilic properties.

DryTec™ technology has two functions.
First of all, the technology provides the screen with excellent moisture-transporting properties. Secondly, **DryTec™** optimizes the PAR shading rate of the screen when there is condensation on it.

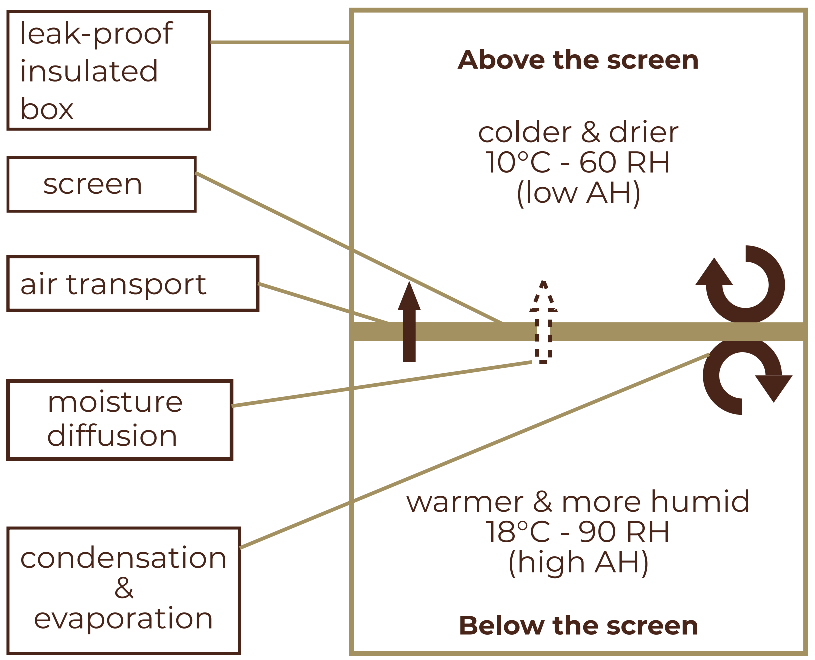
Hydrophilic materials have improved adhesion to water. They are the opposite of hydrophobic materials.
For hydrophobic materials, the adhesion between the material and water is low, whereas it is high for hydrophilic materials. As a result of this adhesion, water that condenses on a hydrophilic screen surface will form a water film.

Traditional screens do not possess this hydrophilic property.
Thanks to **DIAMOND**'s **DryTec™** technology, a water film forms on the screen instead of droplets.
This increases the contact area between the condensation and the moisture-transporting yarns, which facilitates the absorption and transport of moisture through the screen. In addition, the water film optimizes **DIAMOND**'s PAR shading rate in a condensed condition . This is illustrated in Figure 7.

To quantify moisture transport of screens, Wageningen University & Research(WUR) developed suitable measuring equipment as part ofthe Wet Screens project[1].

The device, called TransHumid, of which a conceptual sketch is shown in Figure 6, measures how much moisture (in grams) passes through one square meter of screen per hour under standardized measurement conditions.

Figure 6: Overview of the TransHumid method at WUR



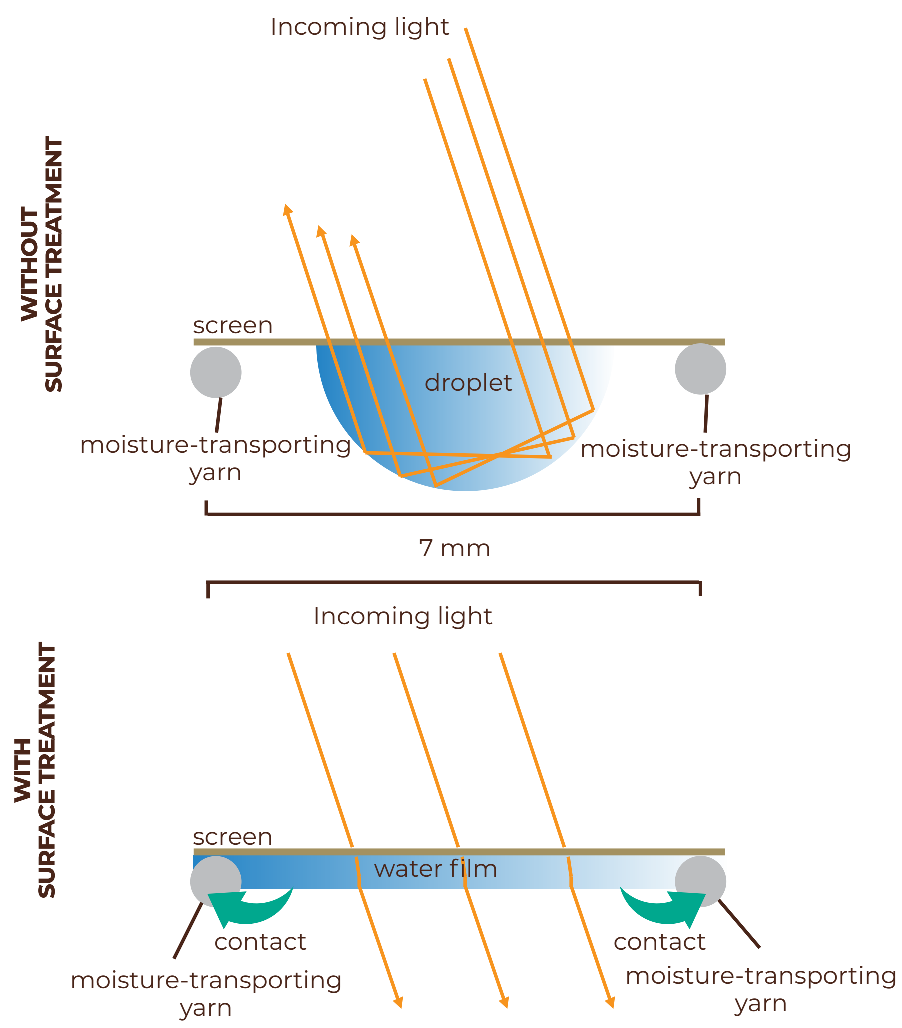
For transparent energy saving screens, the moisture transport rate—measured in the TransHumid under standardized conditions—typically ranges between 20 and 25 g/m²/h . The moisture transport of **DIAMOND**—measured under standardized conditions (see Figure 6) in the TransHumid device—is 21.2 g/m²/h.

In addition to boosting moisture transport through the screen, Phormium's DryTec™ technology also optimizes the transmission of PAR light through the screen in condensed condition . **DIAMOND**'s hydrophilic surface allows condensation droplets to coalesce into a thin water film. This water film reduces the amount of light that is lost due to light reflection off the spherical surface of condensation droplets.

[1] https://edepot.wur.nl/558268

Figure 7 illustrates this principle. The light transmission of a screen that does not have hydrophilic properties is up to 8% lower than that of a screen that does have this particular property.

Figure 7: Illustration of the operation and functions of DryTec™ technology.



TECHNOLOGY

DIAMOND's exceptionally high PAR transparency is made possible by a new **weave pattern patented** by Phormium. In particular, this weave pattern provides **DIAMOND** with higher PAR transmission than traditional transparent energy screens when light strikes at large angles (e.g., 75°). This ensures that DIAMOND transmits more light when exposed to direct sunlight while the sun is low in the sky (winter, morning, evening).

DIAMOND's PAR shading rate for direct light incidence at an angle of 75° is 40.1%. A traditional transparent energy screen has a measured shading rate of 47.9% under these conditions.
Thanks to its high PAR transmission for direct light incidence, **DIAMOND**'s light transmission is also higher under diffuse light conditions.

The PAR shading rate of DIAMOND under diffuse light conditions is 23.6%. A traditional transparent energy screen has a measured shading rate of 27.5% under these conditions.
The above-mentioned PAR shading rates were measured using the **TransVision device of Wageningen University & Research (WUR), in accordance with the NEN 2675 protocol.**

DRYTEC™ TECHNOLOGY

The **DIAMOND** weaving pattern contains less moisture-transporting yarns than a traditional energy screen. Recent studies[1] have thoroughly examined the function of moisture-transporting yarns in a screen.
This research has shown that the moisture-transporting properties of yarns due to their capillary action are often overestimated . Even screens without yarns can have **good moisture-transporting properties**.
Moisture is transported through a screen in three ways. The **primary cause** of moisture transport through a screen is air movement.
This air carries moisture (the relative humidity of the air) with it.

Secondly, there is moisture diffusion. This process is based on the imbalance that exists between the amount of moisture in the space beneath the closed screen, where it is warm and humid, and the space above the closed screen, where it is colder and drier. **Finally**, there is moisture transport through condensation on the fabric, capture and transport of this condensation by moisture-transporting yarns (capillary action) through the screen, and re-evaporation of that moisture at the top of the screen.

Moisture-transporting yarns are not required for moisture transport via air movement and moisture diffusion. Yarns are only needed for the third mechanism (condensation, capture, transport, and re-evaporation). The role of this third process is limited. The contribution of the first two processes to the overall moisture transport of a screen is more important .
A traditional energy screen contains an excessive amount of moisture-transporting yarns.
A major disadvantage of these yarns is that they cause light loss (shading effect).

The combination of DIAMOND's hydrophilic surface and the optimized amount of yarns (DryTec™) enables to significantly reduce the light loss (PAR shading rate) of the screen without compromising the fabric's moisture-transporting properties. The moisture-transporting yarns in DIAMOND, together with the hydrophilic surface, ensure the capture and transport of condensed water through the screen.

47% ENERGY-SAVING

DIAMOND 's weave pattern and the materials used ensure the desired energy-saving properties. These can be further broken down into the following underlying parameters: moisture transport, air transport, and thermal radiation properties. At Wageningen University (WUR), measuring equipment is available to measure each of these three parameters . The devices used to quantify each property are, respectively: the TransHumid, the Permea, and the TNO device.

More information about these devices can be found in the report Wet Screens from Wageningen University[1] (WUR). **DIAMOND**'s score for each of these parameters is in line with the average transparent energy screen.
These parameters are then combined into a comprehensive energy-saving figure. **Similar to traditional energy screens, DIAMOND's energy savings amount to 47%.**

Unlike traditional weaving patterns, **DIAMOND's weave pattern is not prone to fraying**.
The length of the screen can be adjusted simply by trimming it with a hot knife.
Furthermore, **DIAMOND**'s lightweight weave structure (50 g/m²) results in **the same bundle size as that of a traditional energy screen. The bundle size of a screen has a significant impact on the amount of daylight reaching the crop.** This is because even when a screen is not in use, light loss occurs due to the shadow cast by the screen bundle. The shadow caused by the screen bundle of **DIAMOND** or any other traditional energy screen is estimated at approximately 2%.

PhormiTex

Finally, there is the **fabric's fire retardancy**.
There are various standards available for classifying the degree of fire resistance of a screen. The most prominent standard is the Dutch standard NTA 8825.
According to this standard, DIAMOND achieves the highest class , which is Class 1 dr 0.

[1] https://edepot.wur.nl/558268

PAR SHADING RATES APPLIED

PAR SHADING

NEN 2675

So far, **DIAMOND**'s PAR shading rates has been compared to that of a traditional energy screen under static conditions.
The PAR shading efficiency was compared under both diffuse and direct light conditions.

However, a greenhouse is not a static but a dynamic environment. The light conditions are not solely diffuse or direct but vary throughout the day. The position of the sun in the sky (angle of incidence), which has a significant influence on the PAR transmission of a screen under direct light, also changes as the day progresses.

The actual PAR shading rate of a screen is a combination of the PAR shading rate under diffuse light conditions and direct light conditions at specific angles of incidence. A model allows all these factors to be taken into **account in order to compare the shading performance of two screens not under static but under dynamic conditions.**

This provides more in depth insights to the previously mentioned figures, as realistic light conditions are now also taken into account.

Phormium uses a model based on PAR transmission measurements according to the NEN 2675 protocol. For the light conditions, a dataset of weather data from Zevenhuizen in the Netherlands of the year 2019 was used.

Screen and greenhouse configuration

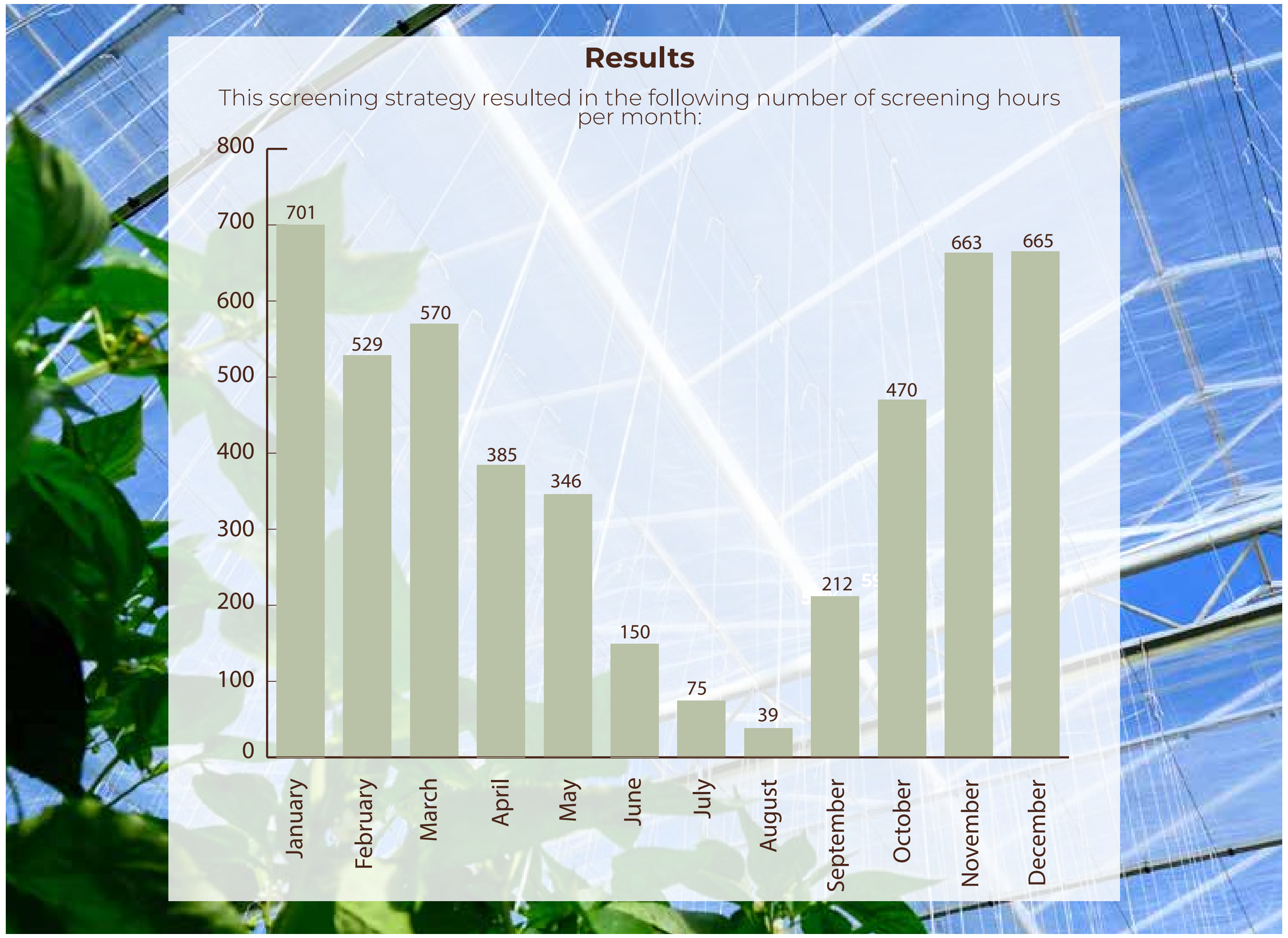
The following scenario was simulated using the parameters listed below.

	Referentie	**Innovatief**
Crop	Tomato	Tomato
Lighting	None	None
Growing cycle	January to December	January to December
Number of screens	1	1
Type of screen	Energy screen	Energy screen
Name of screen	ML 1147	DIAMOND
Location	Zevenhuizen, The Netherlands	Zevenhuizen, The Netherlands
Type of greenhouse	Venlo (glass)	Venlo (glass)
Transmission greenhouse cover	70%	70%

To open and close the screen, the following screening strategy was used, based on the outside temperature and solar radiation:

Outside temperature (°C)	**Radiation (W:M²)**
-10	300
-5	200
0	100
10	50
15	0

Figure 8: Number of screening hours per month resulting from the chosen screening strategy.



To evaluate the PAR shading performance of both screens, the light sum under the closed screen is compared. The ratio of the light sums beneath **DIAMOND** and the reference screen is shown in the graph below.

Graph 9: Average daily light integral (DLI) Beneath Diamond (green) and the reference screen (brown) when closed for each month of the year. The ratio of the green curve (Diamond) to the brown curve (reference) is shown by the brown bars.

Conlcusion

When using **DIAMOND**, the light sum beneath a closed screen is approximately **4% higher** month-over-month. This higher light sum is due to **DIAMOND**'s lower PAR shading rate under both diffuse and direct light conditions. The simulation combines the effects of both into a single figure.

TESTIMONIAL

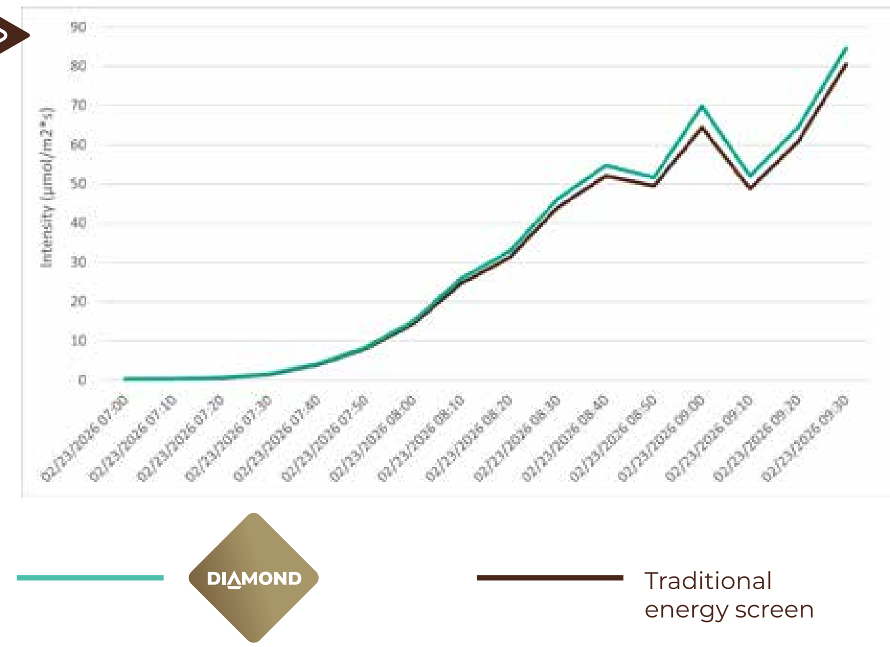
At **Proefcentrum Hoogstraten**, at the end of 2025 **DIAMOND** was installed in one of the compartments of the new greenhouse.

Using a PAR sensor, the light intensity (μmol/m²/s) beneath the fabric was measured and compared with the light intensity (μmol/m²/s) beneath a traditional transparent energy screen in the adjacent compartment. Only one screen was present in each compartment. The greenhouse roof of both compartments was identical, and the PAR sensors were mounted in exactly the same location within the compartments.

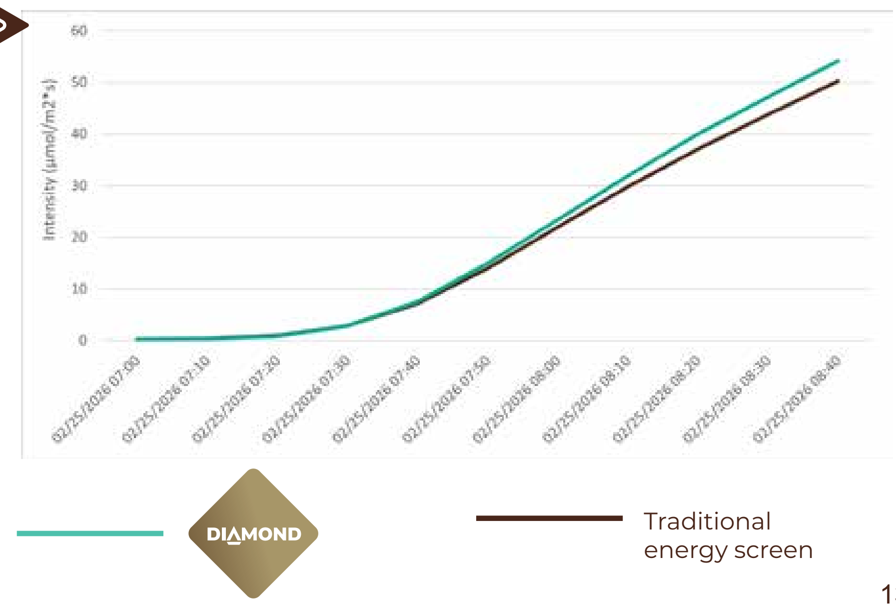
For several days in February 2026, the light sum beneath the closed curtains was calculated from 7 a.m. until the moment the screens opened (same time) and compared with each other. The graphs below show the evolution of light intensity on several days.

"The graphs clearly show higher light levels beneath DIAMOND," says Stef Laurijssen of Proefcentrum Hoogstraten. "Observations from late February 2026 indicate that the light sum beneath a closed screen (from sunrise until the screen opens) is approximately 5% higher with DIAMOND versus a traditional energy screen."

Graph 10: Change in light intensity beneath Diamond (green) and a traditional energy screen (brown) between sunrise and the opening of the screen, measured on February 23, 2026. Measured by Proefcentrum Hoogstraten.



Graph 11: Change in light intensity beneath Diamond (green) and a traditional energy screen (brown) between sunrise and the opening of the screen, measured on February 25, 2026. Measured by Proefcentrum Hoogstraten.



APPENDICES

Parameter	Method	Measure circumstances	Unit	DIAMOND	Reference
PAR-shading	NEN 2675	Diffuse light	%	23.6	27.5
PAR-shading	NEN 2675	Direct light 75°	%	40.1	47.9
PAR-shading	NEN 2675	Direct light 0°	%	15.3	16.4
Moisture transport	WUR Lightlab	10°C 60% RV/ 18°C 90% RV	g / m² / u	21.2	23.1
Energy saving	Phormium		%	47	47
Fire retardancy	NTA 8825		-	Class 1	Class 1

*Table 1: Comparison of **DIAMOND**'s key features with those of the most frequently used alternative.*

NOTES

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