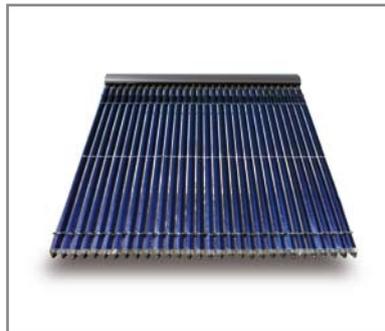
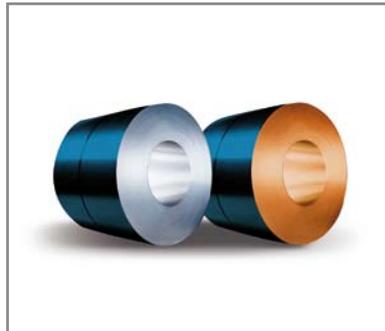


# TiNOX<sup>®</sup> energy





Solar thermal collectors with TiNOX energy absorbers provide heating energy for free and reliably with no environmental impact.

**Maximum yield** Solar thermal collectors use the power of the sun to provide heat for space heating and hot water – for free, reliably, and without an environmental impact. The heart of flat-plate and evacuated-tube collectors is the absorber. It takes up the energy in sunlight and converts it into heat. The more efficient the absorber, the greater the collector's output.

With its highly selective blue TiNOX energy absorbers, Almeco-TiNOX sets industry standards. These products absorb 95% of incident sunlight. At the same time, they only lose some 4% of heat radiation, so that around 90% of the solar energy can be used as heat. In this way, manufacturers of flat-plate and evacuated-tube collectors can ensure the greatest quality and maximum yield for their customers. Almeco-TiNOX applies its highly selective absorber layers both to aluminum and copper substrates in a high-tech coating process. Collector manufacturers are then able to offer a wide range of high-quality products with TiNOX energy.

**Absorber pioneer** No other company in the world has as much experience in the production of highly selective absorbers; after all, TiNOX invented this technology in the mid-1990s and has continued to further develop it since. All TiNOX energy products are made in Germany on modern production lines in Munich and Bernburg (Saxony-Anhalt).

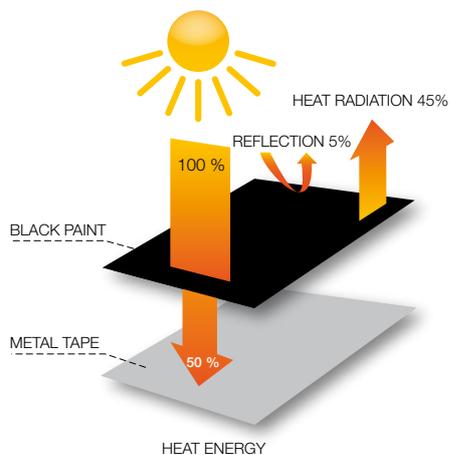
**Best service quality** Almeco-TiNOX is a competent, committed partner for its customers. For instance, the firm has a dense, international service network. Collector manufacturers can therefore fall back on experienced experts worldwide for all technical questions, such as product development, production planning, and training. A high-performance global distribution structure ensures that the absorbers are always delivered reliably, safely, and on time to our customers – regardless of which continent they manufacture on. Almeco-TiNOX also believes that service includes the quick and reliable handling of individual customer demands, such as for special formats or small series. To this end, Almeco-TiNOX has highly precise cutting and pre-fabrication facilities in a number of service centers spread across the globe.



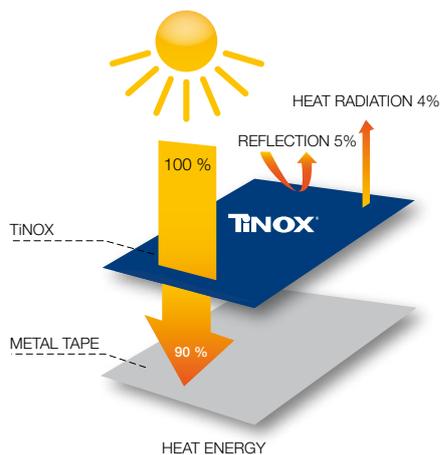
TiNOX is an energy trap. Highly selective blue TiNOX energy absorber coatings take up a lot of energy – some 95% of incident solar radiation – and convert it into heat energy. Conventional absorbers lose a large part of that energy as heat radiation. In contrast, TiNOX energy coatings have an extremely low thermal emissivity of less than 4% in the infrared range to prevent such heat losses. Once the energy has been converted into heat, it stays trapped within the TiNOX absorber.

The high performance of the absorber layer therefore requires the greatest possible degree of absorption within the solar radiation range and the lowest possible degree of emissivity in the heat radiation range. TiNOX energy fulfils this requirement ideally:

**Solar absorption**       $\alpha = 95\%$   
**Thermal emissivity**     $\varepsilon < 4\%$



Both black surfaces and highly selective TiNOX energy products absorb 95 % of incident solar radiation. But black surfaces emit a large part of that energy unused as heat radiation; 45% of the energy is lost. The overall yield of collectors with black coatings is therefore below 50%.



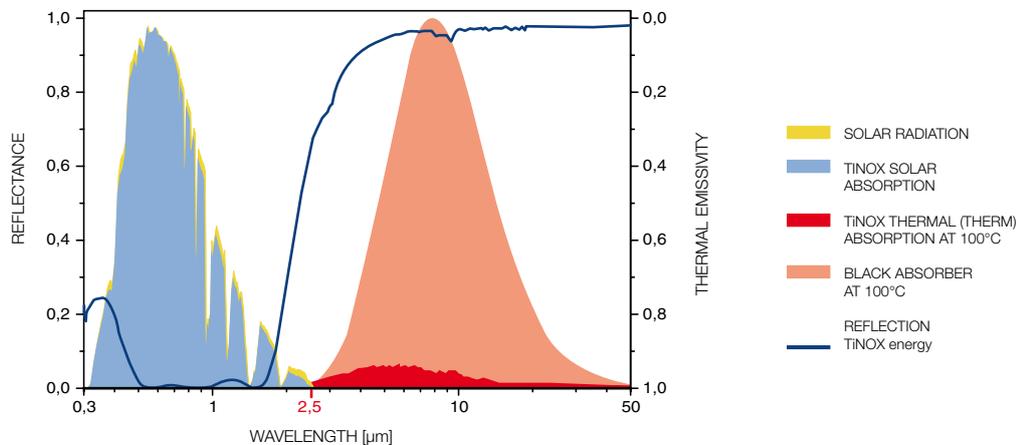
TiNOX energy absorbs 95% of incident solar radiation and converts it into heat. Like an „energy trap,“ highly selective blue TiNOX coatings only lose 4% of the captured solar energy as heat radiation. Around 90% of the energy in sunlight can therefore be used as heat.



Highly selective TiNOX absorbers make use of some 90% of incident solar radiation.

**Selective reflection** Solar absorbers are designed to absorb as much solar radiation as possible and turn it into heat. Black surfaces are well suited for this task. But they also have a major disadvantage – the absorber surface emits some of the energy as heat radiation (infrared radiation). Roughly 50% of the absorbed energy is lost in this manner!

But not with TiNOX energy. These absorbers very efficiently take up solar radiation energy, but they only give off little heat radiation. The trick is to use solar radiation energy at its wavelength below 2.5  $\mu\text{m}$ , while not giving off heat at the cutoff point above 2.5  $\mu\text{m}$ , the characteristic wavelength range for heat radiation from a 100°C surface (maximum operational temperature of a hot water collector). In other words, our absorbers are capable of reacting differently to wavelengths above and below 2.5  $\mu\text{m}$ ; they are selective. This ability clearly reduces heat radiation losses below the level of a black surface.



The blue surface shows how well TiNOX energy absorbs solar radiation. The pale red area represents heat radiation emissions from a black, non-selective coating. The low heat radiation emissions of TiNOX energy are dark red in contrast. The blue curve shows the reflexion response of TiNOX energy. In the range of solar radiation, reflection is very low because the absorber is designed to take up as much energy as possible. In comparison, the coating reflects infrared light very well, resulting in very low heat radiation emissions. After all, as much energy as possible is to remain within the absorber.

**Why is TiNOX blue?** TiNOX energy layers get their colour from the multiple reflections of incident light in the top quartz layer. The light is reflected in the transparent top quartz layer until most of it has been absorbed by the absorber layer. Only a small part of the spectrum – the blue part – manages to leave the quartz layer, producing TiNOX blue's unique colour. The colour is a pure spectrum of light characteristic of the high-quality antireflection layer.



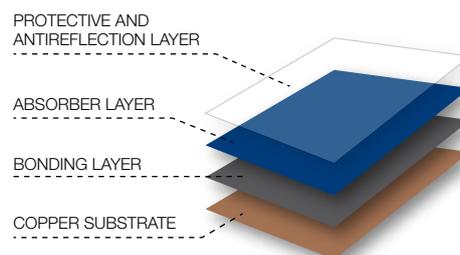
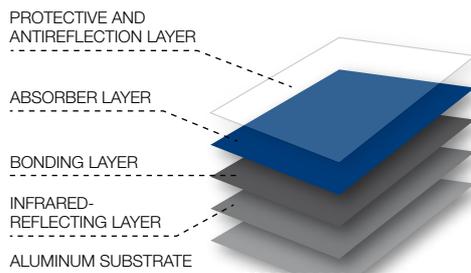
TiNOX energy absorber layers can be deposited both on copper and aluminum. Both substrate **Copper and aluminum** materials have good heat-conduction properties. On request, Almeco-TiNOX also coats other **aluminum** metals.



	TiNOX energy Al	TiNOX energy Cu
<b>Absorption</b>	$\alpha = 95\%$	$\alpha = 95\%$
<b>Emission</b>	$\epsilon < 4\%$	$\epsilon < 4\%$
<b>Width</b>	max. 1,250 mm	max. 1,250 mm
<b>Thickness</b>	0.3 – 0.6 mm	0.12 – 0.5 mm

TiNOX energy consists of a number of carefully designed layers. The substrate material is a highly **High-tech coating** infrared-reflective metal sheet that conducts heat well. A diffusion barrier to prevent metal atoms from entering the absorber layer at high temperatures, which would change the optical properties, is applied to the adhesive layer.

Then comes the absorber layer consisting of a multilayer cermet structure. Finally, an anti-reflective, protective layer of fused quartz is put on top. This material is very hard – and therefore hard to scratch; the absorber is thus very well protected from damage during handling. By minimizing surface reflection, the absorption of solar radiation is further optimized.





The vacuum coating facility in Bernburg is one of the most modern in the world.

When it comes to high-quality coatings for solar applications, the industry turns to Almeco-TiNOX for its highly modern production facilities, the great care it takes in production, its many years of experience, and its comprehensive expertise.

**Pre-handling of metal** High-performance absorber layers require very pure, highly reflective metal surfaces. After all, there has to be as much infrared reflection as possible for the highly selective absorbers to have their typically extremely low emissions. The laws of physics also stipulate that the mirror used cannot be of too high quality.

For TiNOX energy Cu, only the purest copper is used with a pre-cleaned surface. Almeco-TiNOX only works with reliable premium suppliers for this product. The aluminium used in TiNOX energy Al is electrochemically polished, anodized, and sealed by Almeco before being coated.

**Multi-layer PVD coating** The coating is applied in high-tech systems in Munich and Bernburg. In this process, multiple layers of metal and ceramics are applied to metal sheeting in a vacuum. The environmentally friendly PVD (physical vapour deposition) technology is used, in which both electron beam vapour deposition and sputtering are applied.

The whole process is computer-controlled and monitored throughout with optical sensors. In addition, experienced quality engineers carefully visually inspect all absorbers.

**Cutting and packaging** Almeco-TiNOX runs a number of service centres with cutting facilities so that absorbers can be tailored exactly to customer demand. To protect the coating, the sheeting is supplied with foil or paper interlayer. Almeco-TiNOX uses protective foils from the market leader especially developed for high-quality absorber surfaces.

**Environmental impact** Blue TiNOX energy absorbers are green products. Very few resources are consumed during production. For instance, Almeco-TiNOX only needs around a kilowatt-hour of energy to manufacture a square meter of absorber substrate. A single sunny day is enough to get back the energy invested.

The coating procedure is completely emissions-free; in addition, there is no toxic waste unlike conventional black chrome coating, for instance. Not even disposal can worsen the environmental impact of TiNOX energy. The absorber substrate is simply recycled.



A joint venture, Almecco-TiNOX bundles the coating expertise of two firms that have been leaving their mark on markets for a number of years now with their innovations and influence. **The firm**

TiNOX, a spinoff of a research project at the Ludwig Maximilian University of Munich, invented the highly selective blue absorber coating. This technology was a quantum leap in the efficiency of solar thermal collectors. The company name has therefore become synonymous with highly selective absorber coatings. In 2003, the absorber pioneer was integrated in German industrial giant MAGE.

For more than 50 years, Italy's Almecco Group has been manufacturing highly reflective aluminum sheeting for the lighting sector – and more recently for the solar sector. The company is considered one of the world leaders in high-tech aluminum coatings. The Almecco Group has its headquarters near Milan.

Almecco-TiNOX has intensive, long-term partnerships with its customers. Here, collaboration is not limited to the supply of high-quality, high-yield products. As a competent service partner, the firm stands by all of its customers with a wide range of services, including individual consulting, training sessions, and other special services. **Service and consulting**

Almecco-TiNOX is working hard to further improve the efficiency of high-tech solar coatings. To this end, the firm has its own research and development departments in Munich and Bernburg. Almecco-TiNOX also works with renowned research institutes all over the world. **Research and development**

Almecco-TiNOX offers a 10-year guarantee for its TiNOX energy products. A number of renowned testing institutes have confirmed the high quality of TiNOX energy absorber's with their findings. One part of these inspections was the „task X“ test, which simulates the effect of years of temperature fluctuations and exposure to the environment on the absorber's selected layers. Absorbers that pass this test will still provide 95% of their original output even after 25 years. **Warrantees and certificates**

TiNOX energy has the Task X certificate from the following institutes: Institute of Thermodynamics and Heat Technology, Stuttgart (ITW), Fraunhofer Institute for Solar Energy Systems, Freiburg (ISE), Institute of Solar Technology, Rapperswil College (SPF), and Swedish National Testing and Research Institute. Almecco-TiNOX also has DIN EN 9001:2000 certification. This certificate confirms the high quality assurance at Almecco-TiNOX.





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