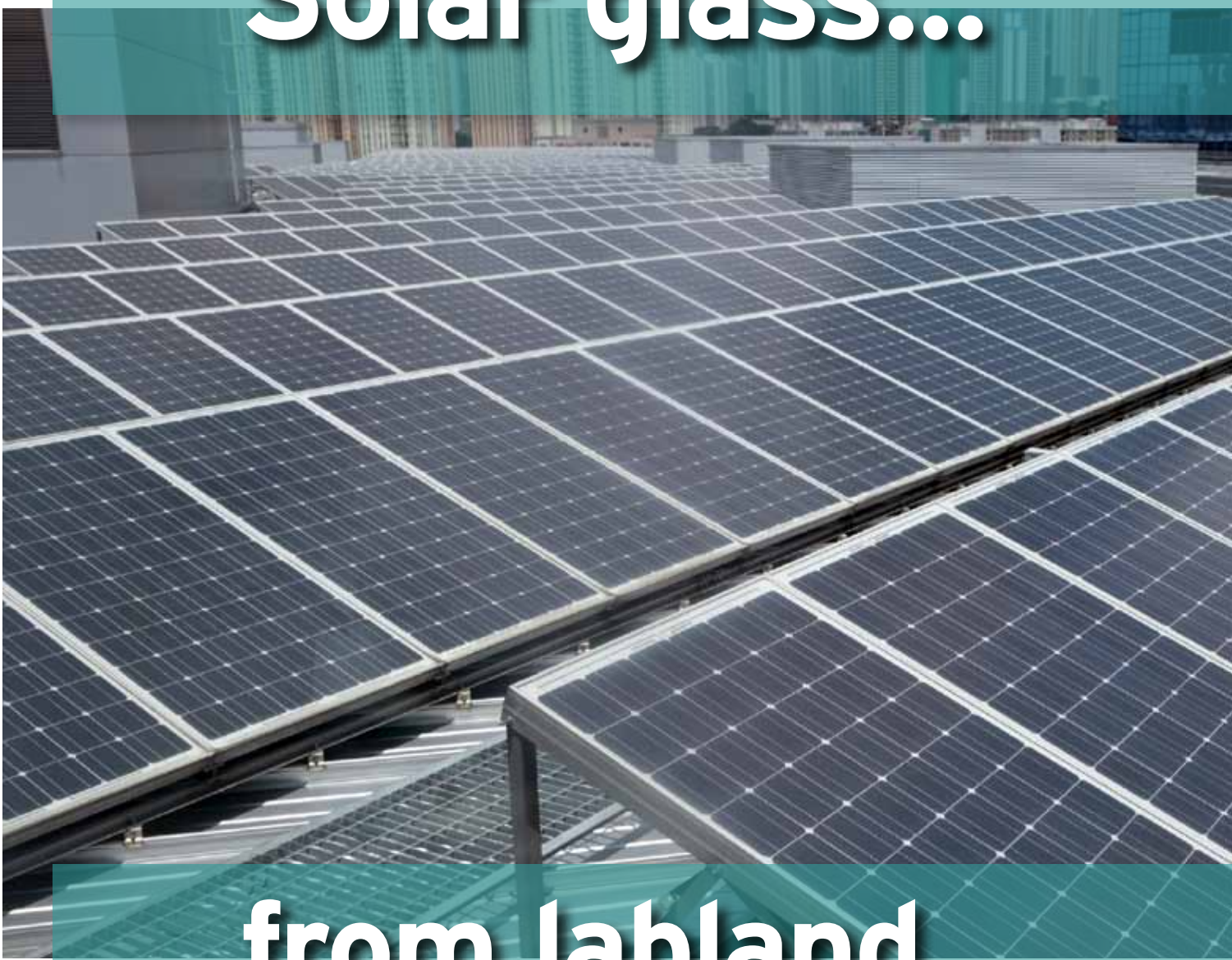
Solar glass...



from labland to reality for real added value

Stephen Byers, Ritec International

Much time, effort and money are spent on options for glass in solar energy panels which add to costs but can also create 'added value'. Depending on the type of panel, thermal for heating or photovoltaic (PV) for electricity, basic added value comes from glass processing such as toughening, laminating or bending. Other options that maintain or improve the original light transmission are highest in value, because there is a direct relationship between light transmission of glass in a solar panel and its output in heat or electricity.

When light transmission drops, output is less and this reduces added value. Therefore, it is important to consider ways of keeping the original light transmission, otherwise costs can easily rise and output drop to a point where investments in the options for glass will be lost or wasted. This risks solar glass being marketed as a commodity item, when it should be a speciality product perceived as high in value.

Labland creates another risk to perceived value. The solar panel industry relies on numbers for comparisons of output and other features, but these numbers are based on laboratory conditions and theoretical calculations instead of actual conditions. These numbers may not be achieved when solar panels are exposed to real life field conditions, risking damage to the reputations of companies and the industry in general.

Stephen Byers, Managing Director of Ritec International Limited, reviews the ways that manufacturers, distributors, installers and end users of solar panels are avoiding such risks by following the experiences of architectural and marine glass during the past 30 years. Stephen looks at the benefits to everyone in the solar panel supply chain of moving from Labland to reality and keeping added value high by maintaining the original light transmission.

15 Degree Fallacy Increases the Risks

Frequently it is believed that rainfall and wind will clean solar panels installed at an angle of 15 degrees or more. This is easily proven to be a fallacy, but it costs the solar power industry lots of time, effort and money - a situation that can be avoided by learning from the experiences of other markets such as architectural and marine glass.

Until 30 years ago, glass in buildings and marine vessels was known to be highly susceptible to dirt and high in maintenance because it required frequent and sometimes intensive washing. This situation was accepted or tolerated because there was no practical solution at that time.

When Ritec International Limited pioneered durable glass surface protection for cruise ships and ferries in 1981, there was a general misconception that dirt on exterior glass could easily be washed away by rain and wind, or by spraying the glass with tap water. This may have worked when the glass was new, but not after months or years of glass surface corrosion. It may have worked for "non-bonded" or "loose" dirt, but not for dirt firmly bonded to the glass surface as shown below.

Later Ritec found that glass in land-based buildings suffers from the same types of dirt - bonded and non-bonded – but coming from different sources. This was a major discovery that started development of an innovative and award-winning system for glass renovation, protection and maintenance.

Now there is a growing demand for glass in solar panels, both thermal for heating and photovoltaic (PV) for electricity. Similar to the experiences of architectural and marine glass three decades ago, there are misconceptions and misunderstandings about dirt on solar panel glass. Learning from these experiences and taking actions to reduce the risks will benefit all in the solar panel supply chain – fabricator, distributor, installer and end user.

Different Market Requirements... One Major Factor in Common

Glass is used in the exterior of buildings and marine vessels mainly because it is the material of construction that transmits the broadest spectrum of sunlight – providing visibility, 'daylighting' and a connection with the outside world. For marine vessels, this also means safety of passengers and crews.

For solar panels – thermal or photovoltaic (PV) - visibility is of course not required but light transmission is crucial. There is a direct relationship between transmission of sunlight and output of energy – heat or electricity.

Dirty architectural and marine glass has poor visibility, daylighting and appearance. For solar energy panels, visibility is not a requirement and appearance may or may not be secondary.

There are differences in the requirements of these three market sectors, but there is one important requirement in common – **optimum light transmission** – which creates a need for **clean glass**. Unfortunately, dirt gets in the way!

Dirt on Solar Glass

There are two general categories of dirt on solar glass:

- **bonded dirt** – cannot easily be washed away using conventional methods because it chemically reacts with glass to form a strong attachment.

  Scientific studies show that bonded dirt accounts for a minimum of 3% loss in light transmission and power output of PV solar panels.

- **non-bonded dirt**, commonly known as "loose dirt", such as dust, pollen and other particles – easily washed or rinsed away using conventional methods because it is not chemically bonded.

  Scientific studies show that non-bonded dirt causes a PV solar panel to lose light transmission and power output at least 6% and many times up to 20% or more.

> "Labland creates another risk to perceived value. The solar panel industry relies on numbers for comparisons of output and other features, but these numbers are based on laboratory conditions and theoretical calculations instead of actual conditions"

Dirt, both non-bonded and bonded, are major causes of shading described below. A relatively small surface area of glass shaded by dirt can reduce energy output by significant amounts. For example, the effects of dirt on solar glass is so great that it can quickly and easily negate the typical eight (8) percentage point increase in light transmission produced by a combination of low iron glass and an anti-reflective (AR) coating. As a result, resources invested in these two added value features easily become lost or wasted.

Shading – Sometimes Obvious, Frequently Hidden

Shading is a major enemy of solar energy output simply because it restricts or blocks the transmission of sunlight through solar glass. This can be anything that restricts or potentially limits light transmission, including shadows of trees or features of buildings such as roofing, chimneys or antennae. Snow is another serious cause of shading as shown in the photograph.

Thermal solar panels are able to tolerate some shading, but PV panels are very sensitive to a small reduction in sunlight. For example, shading only one of 36 cells in a typical PV panel (2.8% of the surface area), causes a drop in electricity output of up to 50%.

Shading from the shadow of a distant tree or building reduces light transmission because the sunlight is diffused or dispersed. Shading from directly above or on a PV panel, such as a tree branch or bird droppings, stops light from reaching PV cells in the panel and this can cause output of the panel to drop to 50% of its un-shaded value.

Glass surface corrosion can cause shading when it reaches a stage of etching the surface and making it appear white. The root causes of glass surface corrosion are:

- moisture, both liquid and vapour – from seawater and tap water;
- alkalinity – including residues of seawater and hard tap water.

A serious, but often unseen, cause of shading is dirt. The negative effects of dirt can be measured within a relatively short period of time. For example, a two-month study in central Athens (August-September 2009) using PV solar panels installed at an angle of 30 degrees and no cleaning of the glass showed significant losses in light transmission and energy output.

Added Value Options for Glass in Solar Energy Panels

Standard float glass adds value because it protects the internal components of a solar panel, does not reflect solar rays and is the material of construction that transmits the broadest spectrum of sunlight. More value is added through glass processing, depending on the type of solar panel and its purpose. The glass may be flat, curved or formed into cylinders. It can be toughened or laminated for reasons of safety.

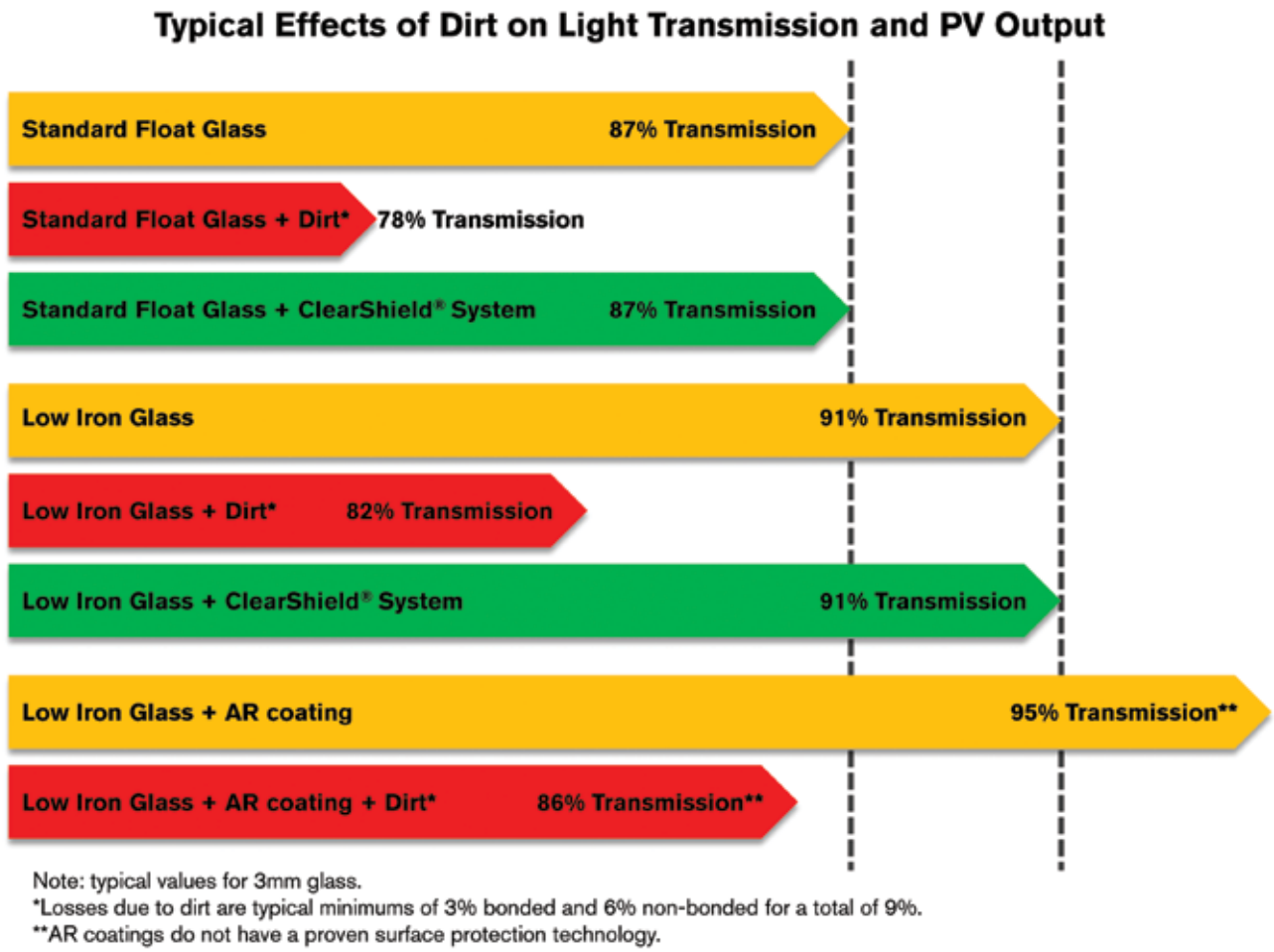
The options adding highest values to solar panel glass, generally speaking, are those designed to improve or maintain the all-important transmission of sunlight:

- **low iron glass** – specially produced to minimise the iron oxide that gives standard float glass a green tint and restricts light transmission.

  New low iron glass typically has 91% light transmission (3mm thickness) compared with standard float glass at 87%, for an increase of four (4) percentage points. However, as described below, this initial improvement can quickly and easily be negated by dirt.

- **Anti-reflective (AR) coating** – mainly based on silicon dioxide (SiO_2), the primary component of glass, has:
  - a microscopically rough surface with many places for dirt to bond
  - an affinity for moisture, a major cause of glass surface corrosion
  - low resistance to alkalinity, another major cause of glass surface corrosion.

  AR coatings typically increase light transmission of 3mm glass by four (4) percentage points, so if applied to low iron glass the result is typically 95%. However, as described below, this initial improvement can quickly and easily be negated by dirt.



- **ClearShield® glass surface protection with "non-stick", easy-clean performance –** based on a special polymeric resin with strong resistance to moisture, alkalinity and other causes of glass surface corrosion. The only glass surface protection proven in performance and durability for 30 years under actual field conditions.

ClearShield® works on any type of glass, including standard float and low iron, to maintain original light transmission.

ClearShield® does not work on AR coatings, therefore optimum results for light transmission are achieved by applying ClearShield® to low iron glass.

The Labland Numbers Race

Labland, meaning a state of reliance on numbers from theoretical calculations in a laboratory environment - instead of actual conditions - to make comparisons of solar panels. Labland risks solar panels losing their perceived added value and being marketed as a commodity.

PV solar panels are normally advertised and compared by a number called 'peak power' or 'rated capacity' - a calculated figure that represents the potential power that a module can generate under certain Standard Test Conditions (STC) set by the industry. Other measures for solar panels include rated power, peak power, cell efficiency, module efficiency and capacity factor.

The peak power output of PV solar panels is typically about 15%, meaning that 85% of sunlight reaching the panel is not converted into electricity. The output is reduced even further by 'shading' as described below.

STC testing is generally based on conditions of 1,000 watts per square meter solar irradiance at 25 degC cell temperature, air mass equal to 1.5 and a certain standard spectrum. This is basically the level of sunlight at the equator at noon, but testing is under ideal conditions in a laboratory and does not reflect real world exposure.

This situation is considered as similar to advertising a car with top speed of 300 miles per hour knowing this is not practical or possible in real life, or advertising 50 miles per gallon (mpg) knowing this mileage is only achieved on a test track under controlled conditions, and that 30 mpg is all you can achieve under actual driving conditions. Failing to meet users' expectations risks damage to the reputations of companies and the industry in general.

Realities of PV Solar Panels Exposed to Real Life Conditions

When new, glass in PV panels typically shows light transmission as follows:

- standard float glass, 3mm = 87%
- low iron glass typically adds four percentage points = 91%
- AR coating typically adds four percentage points = 95%.

With exposure to real life conditions, dirt can quickly and easily negate the above numbers:

- bonded dirt – typically a minimum reduction in light transmission of three percentage points, negating benefits of the AR coating;
- non-bonded or loose dirt – typically a minimum reduction in light transmission of six percentage points minimum, negating benefits of the low iron glass.

Therefore, dirt can easily negate the increases in light transmission initially gained by adding a combination of low iron glass and AR coating. Keeping in mind that these figures are considered as minimums, the actual reductions can easily be much greater.

The Growing Demand for Cleaner, Greener Glass

Sunlight is an essential part of our lives and provides the fuel for solar energy panels. Solar energy panels are often promoted on the basis of being "green" because they do not require fossil fuels or have emissions. However, solar panels with dirty glass cannot be considered as green because they require cleaning more

frequently with greater increased energy consumption through manpower, cleaning chemicals, water, fuel and other resources.

Even with frequent and intensive washing, ordinary glass becomes increasingly difficult to clean and keep clean. Its bare, unprotected surface is exposed to the causes of glass corrosion and easily becomes stained or discoloured by contaminants that bond firmly and cannot be removed by conventional cleaning methods.

The proven solution is durable glass surface protection with "non-stick", easy-clean performance. Ritec's ClearShield® is the first and only technology meeting these requirements, and has met the test of time with 30 years of experience on glass in all types of buildings, marine vessels and transportation vehicles worldwide.

ClearShield® keeps glass in solar panels, thermal and PV, cleaner and greener by helping to keep the original light transmission, power output and added value. This enables us to keep our word and safeguard the industry's reputation.

ClearShield, the ClearShield System and ClearShield "Non-Stick" Glass are trademarks of Ritec