

Considerations for installing photovoltaic arrays on industrial and commercial buildings



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TATA STEEL

Tata Steel is one of Europe's leading steel producers, with steelmaking in the Netherlands and the UK, and manufacturing plants across Europe. The company supplies high-quality steel products to the most demanding markets, including construction and infrastructure, automotive, packaging and engineering.

Our approach to business is unique. We believe our strength is how we build collaborative relationships that create new success for our customers, adding value to their business and helping them to perform in their markets. As a company, we are dedicated to managing our operations responsibly and to continuously improving our performance. We operate in a way that is safe for our people and which respects the environment, with care towards the communities surrounding our operations and beyond.

Sustainability

Steel is an essential material, intrinsic to our way of life and to the products society will demand in a sustainable future. Steel is a material that is used, not consumed. It is recycled and used again, without any loss of quality, time after time.

At Tata Steel, we are committed to making the products society needs and to making them in the most responsible way possible.

This means, practically, that we commit to:

- Producing steel products for the future.
- Investing in sustainable steel making.
- Improving our existing processes.
- Facilitating the recycling loop.

Environmental Product Declarations

Tata Steel have published product specific Environmental Product Declarations (EPD) for both Colorcoat HPS200 Ultra® and Colorcoat Prisma® that comply with EN 15804 and ISO 14025. Please visit www.colorcoat-online.com/epd for further details.

UK targets for renewable energy generation

The European Union has set targets, to increase the use of renewable energy technologies and reduce greenhouse gas emissions. While these have been Europe wide, individual countries have the ability to set their own additional targets.

The UK target for 2020 was 15% energy from renewables and this has been achieved. The European block target for 2030 is 32% of energy from renewable sources Figure 1 shows the predicted increase in electricity generation from renewable technologies (science direct <https://www.sciencedirect.com/science/article/pii/S0301421515002037>).

A report by the National Infrastructure commission states that the UK should be running at 50% renewable energy by 2030 to set a cost effective path to net zero emissions by 2050.

Renewable energy technologies in 2019 accounted for 36.9% of all electricity generated in the UK. This figure has shown a year on year growth and is predicted to continue this trend see figure 2: Department for Business, Energy & Industrial Strategy. UK Energy Statistics 2019 & Q4 2019.

The renewable electricity generation is spread across a range of technologies with Solar photovoltaics producing around 13%. In 2019 this equated to 6% of the total electricity generation.

Figure 1: Percentage of Change in Renewable Energy Sector Share from 2010 to 2030

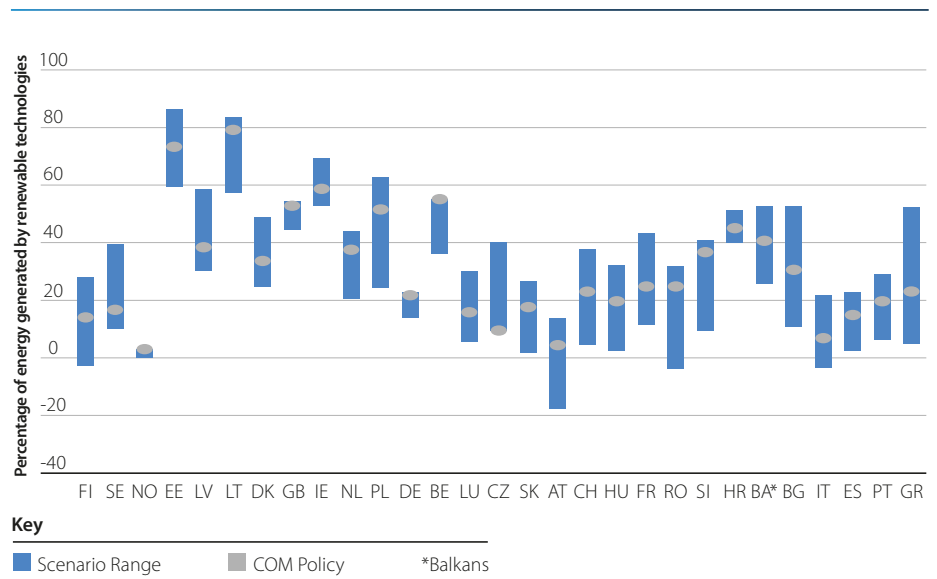


Figure 2: UK Electricity Generated by Technology

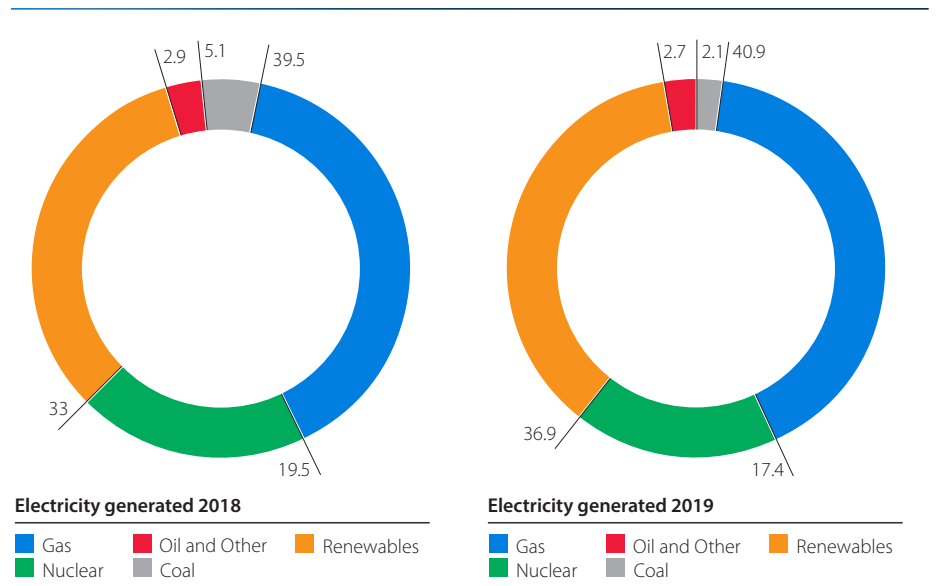
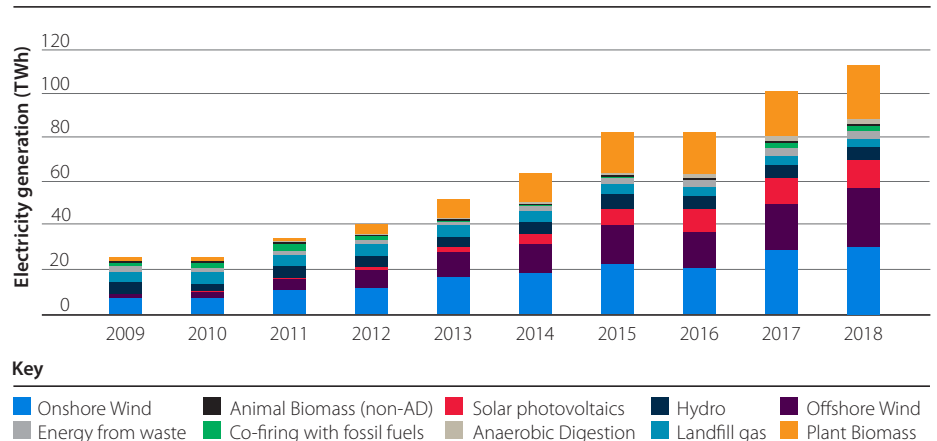


Figure 3: Electricity Generated by Different Renewable Technologies in the UK



(https://en.wikipedia.org/wiki/Renewable_energy_in_the_United_Kingdom#/media/File:UK_renewables_generated.PNG).

There has been a large increase in the number of roof top photovoltaic (PV) installations over recent years. This has been driven by a number of factors including:

- As a Part L compliance strategy
- As a financial investment
- As part of the building owners sustainability agenda

When considering installing a roof mounted PV array, the building owner needs to consider a number of criteria.

1. Building suitability
2. Building structure
3. Financial viability
4. Pre-finished steel cladding selection
5. Safety
6. Guarantees and maintenance
7. Cladding system manufacturers' recommendations

Table 1: Effect of roof pitch and orientation on PV output

	Vertical	80°	70°	60°	50°	40°	30°	20°	10°	Horizontal
E	58%	65%	70%	76%	80%	84%	86%	88%	90%	90%
SE	69%	77%	84%	89%	93%	96%	96%	96%	94%	90%
S	71%	80%	87%	93%	97%	100%	100%	98%	96%	90%
SW	67%	75%	82%	87%	92%	95%	96%	96%	94%	90%
W	56%	63%	69%	74%	78%	82%	86%	87%	89%	90%

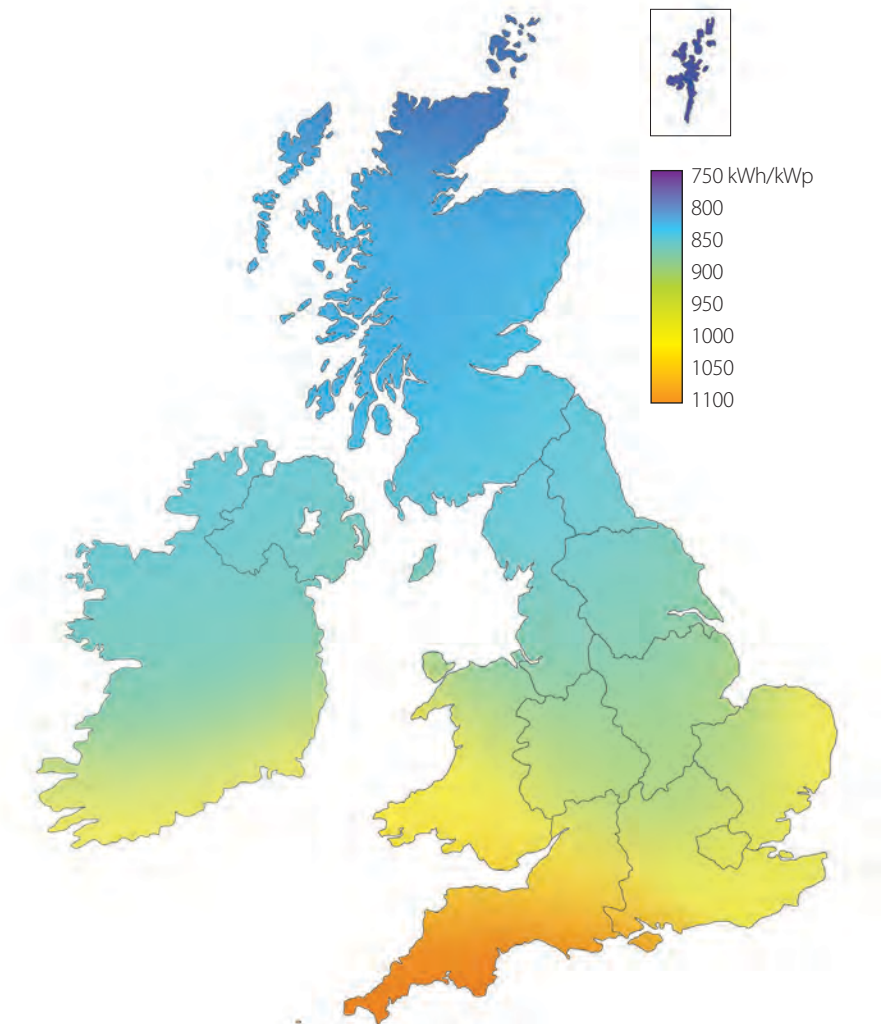
Building suitability

Does the building have suitable roof elevations and are they favourably oriented without shading from adjacent buildings or trees?

The optimum roof orientation is due South with a 30 to 40 degree pitch. As the installation moves away from the ideal orientation the overall efficiency will decrease. Roofs which have a more easterly orientation will generate more electricity in the morning and more westerly orientations will generate more electricity in the afternoon. As the roof pitch decreases so the effect of moving away from a due south orientation becomes less significant.

The size of a PV array is quoted in "kilowatt peak" which is based on the nominal output of the PV panels under test conditions. The actual quantity of electricity generated will vary with building orientation and location within the UK. An installation in the South of England could generate at least 50% more electricity than a similarly sized installation in Northern Scotland.

Figure 4. Typical UK annual photovoltaic electricity generation



Building structure

A PV installation can impose significant additional loads on to the building structure.

Dead load

The type, weight and number of PV panels being installed will affect the total dead loading. There is a very large difference in the weight of PV panels, which range from around 4Kg/m² up to 20+Kg/m². Where the structural capacity is an issue, the specifier should consider the benefits from using a lightweight system, which may be slightly more expensive but will have lower structural cost implications.

Wind loadings

PV panels can create significant additional wind loadings, particularly around the

perimeter of the array and if the panels are installed at an incline to the roof pitch. BRE document DG489 gives guidance on how these should be calculated.

If the installation is part of a new build, the additional loadings must be factored in to the structural calculations. In some cases this may result in larger steel sections having to be specified.

For a retrofit installation, a full structural survey of the existing structure should be carried out to assess the additional loads which can be applied.

Loading of panels onto the roof prior to installation.

PV panels are usually supplied in container crates. Care must be taken when loading PVs on to the roof structure (prior to laying out) that the localised load does not exceed the capability of the building structure. If possible it is advisable to design loading bays into the scaffolding.



Financial viability

There are a number of factors to consider when calculating the financial viability of a system and financial payback.

Installation of a PV system for Part L compliance

The CO₂ saved from the electricity generated by the PV system can be offset against the overall building emission rate. Due to the relatively large CO₂ savings and financial payback from most PV systems this is one of the most financially attractive options for compliance, however it does generally have higher initial capital cost than improvements to the building envelope or services.

Initial system installation costs

Initial system installation costs can be broken down into a number of areas:

- Solar PV panels.
- Mounting systems.
- Inverters.
- Generation meters.
- Installation.

The overall installation costs have reduced to less than one third of those being quoted in 2009. Costs are very dependent upon the size of the array with larger systems being installed for less than £1000/kWp.

A number of companies will now offer fully funded PV installations as part of a power purchase agreement. The building owner/occupier agrees to purchase electricity at an agreed rate which is lower than the current commercial rate. The provider installs and maintains the PV system for the duration of the agreement. The provider generates a return on investment through the sale of electricity.

Maintenance and upkeep

A PV system will require routine maintenance and upkeep to maintain the electrical output at the highest level. This will include items such as cleaning of the panels and the cladding underneath the panels, inspection of the panels, brackets and electrical installation. Most inverter units will require replacement at least once during the array lifetime.

Use of the electricity which is generated

The electricity generated by the PV installation can either be used by the building owner/occupier or exported back to the grid. The sell back to the grid price is much lower than the normal commercial cost of electricity, so it is far more financially attractive if the owner/occupier can use as much of the electricity generated.

Note

For installations greater than 30kWp, the owner must install metering on what is being exported back to the grid. Below this threshold, unless a meter is installed, it is assumed that 50% of the electricity generated is used by the owner and 50% is exported to the grid. In practice, this makes it even more attractive for smaller arrays where the occupier uses most/all of the electricity generated.



Pre-finished steel selection

When a PV array is installed over a pre-finished steel cladding system, a local environment is produced, which can be significantly different from freely exposed roof cladding.

Table 2: Effect of installing a PV array on the pre-finished steel

Element	Normal roof cladding	Cladding under PV panels
Rain	Subject to normal rainfall and washing effect of raindrop impact	Normal water flows down profile troughs but no direct rainfall
Air movement	Open access, allowing drying of the sheeting	Restricted access, with limited air movement
UV radiation	Paint is fully exposed	Minimal exposure between panels

Detailed examination of roof cladding underneath PV arrays have shown that there is an increased risk of dirt build-up and algae growth, due to:

- Reduced cleaning effect of natural rainfall.
- Reduced airflow over the cladding.
- Increased time of wetness/increased relative humidity.

This dirt build up can contain corrosive salts, particularly in coastal and heavy industrial environments. There is also potential for larger objects such as litter, leaves, twigs etc to get caught behind the panels which can restrict water flow down the profile troughs and can also create a damp poutlice with associated increased corrosion risk.

While the area underneath a PV array is not subject to UV radiation which can be particularly harmful to pre-finished steel, this benefit can be outweighed by the more aggressive local environment.

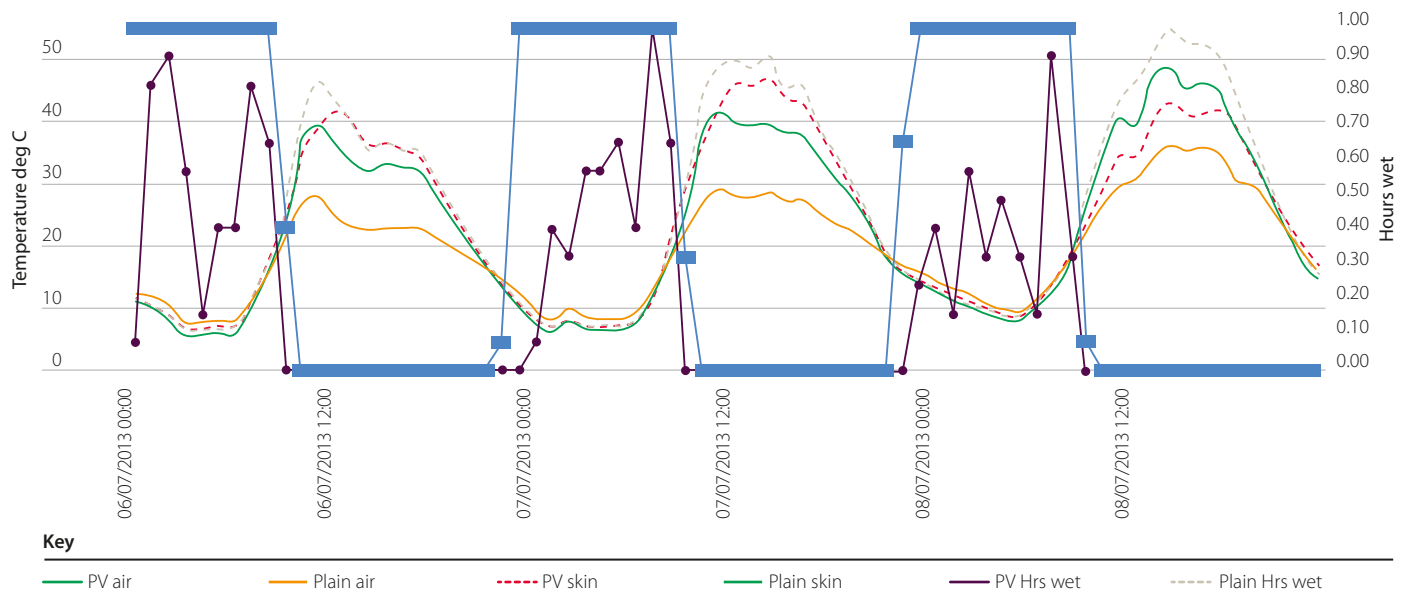
Tata Steel have carried out an extensive assessment of the local corrosion environment created underneath a PV array, using a combination of environmental monitoring sensors and mild steel corrosion coupons to measure the increased corrosion risk. Local sensors have been used to measure the temperature, relative humidity and time of wetness behind the PV panels and for adjacent freely exposed roof sheeting. The area underneath the PV panels had a higher relative humidity and increased time of wetness. The air temperature was also more variable, with warmer maximum temperatures and colder minimum temperatures. This led to a visible increase in condensation which mainly formed on the underside of the PV panel.

Standard mild steel corrosion coupons have been subject to 2 years exposure. The coupons underneath the PV array show significantly greater levels of corrosion and pitting than the coupons which were freely exposed. This is

also more pronounced on the upper surface, due to increased condensation dripping on to the top surface of the coupons. This confirms the more aggressive corrosion environment underneath the PVs.

While the corrosion environment is more aggressive, the pre-finished steel underneath the panels will not be subject to direct UV radiation. This is potentially the most damaging element contributing to the breakdown of organic coatings and exposure of the steel substrate.

Figure 5: Environmental monitoring data. Freely exposed roofing and area under a PV array



These factors combine to create a significantly more aggressive local corrosion environment underneath the PV panels.



Mild steel corrosion coupon underneath PV panels showing heavy red rust and flaking.



Mild steel corrosion coupon on freely exposed cladding showing lighter surface corrosion.

To minimise the risk of corrosion, the architect should specify a roof or wall cladding material which has been assessed for use with a PV array and has an application specific guarantee.

Tata Steel have carried out extensive testing of Colorcoat HPS200 Ultra® and Colorcoat Prisma®; the Confidex® Guarantee will remain valid for up to 40 years underneath a PV array, provided the additional inspection and maintenance requirements of the PV addendum are complied with.

Safety

Where a PV array is planned, the principle designer needs to ensure that the installation meets the requirements of the CDM regulations.

The installation of a roof mounted PV array will increase the future requirements for work on the roof. The designer must take this into account and ensure that the array is installed in such a manner to minimise the risks associated with working at height.

Safe access on to a roof for installation/cleaning and maintenance activities is important:

- Non fragility. By specifying a non fragile roof system which has met the requirements of the ARC safety test regime, the risk of falling through the roof is reduced. It must be noted that when planning to work on a roof, the assembly should be considered fragile until demonstrated otherwise by visual/structural inspection.
- Walkability. The increased activity on the roof around the PV array, means that the roof cladding is more prone to damage. Specifying a roof cladding sheet which is classed as walkable, ie can resist a localised force of 0.9kN over an area of 200mm square will reduce the risk of any permanent damage to the roof cladding.
- Fall protection. When working on a roof, an adequate system of fall restraint or fall arrest should be used. The PV array should be installed such that there is easy access to all areas of the array while maintaining a safe system of work. This may require the installation of additional roof safety lines.

Guarantees and maintenance

Prior to installing a PV array, the specifier, should understand the guarantees associated with the PV installation and how the installation will affect existing guarantees.

Pre-finished steel

Most pre-finished steel guarantees are only applicable for freely exposed normal roof or wall cladding. The Confidex® Guarantee for Colorcoat HPS200 Ultra® and Colorcoat Prisma® will remain valid for up to 40 years underneath a PV array, provided the terms and conditions of the PV addendum have been followed.

The roof cladding system

Any additional loads applied to the cladding system must be calculated to ensure they are within the system capability. The PV installation should follow the system manufacturer's guidelines. Any failure of the cladding system due to the PV installation would not normally be covered

PV panel

Most panel manufacturers will quote two guarantee figures:

1. A manufacturer's warranty which is usually for 10 years. If failure occurs within this period, the manufacture will replace/repair/compensate according to their terms and conditions.
2. A limited power output warranty. This states the expected power output from a panel as a % of the original output and how it will drop off over a period of time, usually 25 years.

Inverter

Inverters will usually require replacing at least once during the life of the installation. Guarantees are typically for 10 years with options to purchase extended periods up to 20 years.

Installation

The installation contractor will usually offer a guarantee on workmanship of up to 10 years (maybe 12). The specifier should ensure that the contractor is MCS accredited and is experienced in installations on metal cladding systems.

Cladding system manufacturers' recommendations

- A PV array should be installed such that it meets all the recommendations associated with the existing or proposed roof cladding system.
- Specify the most durable roof cladding material due to the more aggressive local environment underneath the PV panels.
- Ensure that the cladding guarantee will remain valid once a PV array has been installed.
- The PV array should be installed to allow access to the roof to allow effective inspection, cleaning and maintenance. This includes plant/ducting etc which have been installed on the roof and require periodic maintenance as well as the PV panels/array.
- The array should be zoned with suitable walkways which allow access to individual panels within the array. It is sensible to locate walkways over purlins as this is one of the most structurally sound areas of the roof.
- Consideration should be given to the more vulnerable areas of the roof cladding system such as areas around roof lights, end lap joints and penetrations through the cladding.

For further information please contact our technical helpline
Colorcoat Connection® helpline: T +44 (0) 1244 892434





The Colorcoat® brand

The Colorcoat® brand provides the recognised mark of quality and metal envelope expertise exclusively from Tata Steel. For 50 years Tata Steel has developed a range of technically leading Colorcoat® pre-finished steel products which have been comprehensively tested and are manufactured to the highest quality standards. These are supported by a range of services such as comprehensive guarantees, colour consistency and technical support and guidance.

Colorcoat® products are manufactured in the UK and are certified to independently verified international management system, ISO 14001 and are fully recyclable, unlike many other construction products.

Colorcoat® products and services

Colorcoat® products offer the ultimate in durability and guaranteed performance reducing building life cycle costs and environmental impact.

We have detailed Life Cycle Costing and Life Cycle Assessment information that demonstrates the positive performance of Colorcoat® products when compared with other alternatives. This is available from www.colorcoat-online.com

Colorcoat® BES 6001 approved

Colorcoat® pre-finished steel products manufactured in the UK are certified to BES 6001 Responsible Sourcing standard, the first steel envelope products in the world to achieve this.

Colorcoat HPS200 Ultra®

Colorcoat HPS200 Ultra® pre-finished steel combines outstanding performance with exceptional durability being designed to withstand even the most demanding and aggressive environments.

Colorcoat Prisma®

3 layer Colorcoat Prisma® provides enhanced aesthetics, durability and long term performance. The latest pre-finished steel product not only pushes the boundaries for UV performance but also outperforms the highest European corrosion resistance standards. This makes it the ideal choice for commercial, retail, warehouse, public sector, and superior aesthetic buildings that are truly built to last.

Whatever your type of building from warehouses and distribution facilities, schools and offices, Colorcoat Prisma® offers you a range of attributes that enables you to create beautiful, modern and durable roofs and walls, Confidex® guaranteed for up to 40 years.

Confidex® Guarantee

Offers the most comprehensive guarantee for pre-finished steel products in Europe and provides peace of mind for up to 40 years for both products upon registration. Unlike other guarantees, Confidex® covers factory cut edges for the entirety of the guarantee period with no requirement for any inspections or maintenance to validate the guarantee except when Colorcoat HPS200 Ultra® and Colorcoat Prisma® are used on a roof or wall that has a Photovoltaic (PV) installation. Available only with Colorcoat HPS200 Ultra® and Colorcoat Prisma®.

The Confidex® Guarantee includes cover for Colorcoat HPS200 Ultra® and Colorcoat Prisma® under photovoltaic (PV) modules for the full guarantee period. PV modules can be installed at any time during the Confidex® Guaranteed Period and the pre-finished steel will be covered for the remainder of the guarantee period.

For further information on Colorcoat® products and services please contact the Colorcoat Connection® helpline on +44 (0)1244 892434 or email colorcoat.connection@tatasteeleurope.com Alternatively visit www.colorcoat-online.com



Colorcoat® technical support team

Colorcoat® products are supported by a comprehensive range of services, technical advice and guidance. Our knowledge and expertise of the complete range of building envelope systems available with Colorcoat® products, means that the advice and support that we can offer you is truly objective.

We can help you to achieve the best technical solution for your building with the optimum in performance and environmental credentials. If you are building to specific sustainability credentials or performance criteria, we can work with you at the design phase of your project to help you integrate these requirements and deliver technically superior buildings that match your vision.

Colorcoat Connection® helpline

This dedicated helpline offers immediate and easily accessible advice and guidance on a wide range of construction industry issues.

Whether you require information on the latest building regulations, calculations for

a specific project or advice on integrating renewable technologies you can contact the Colorcoat Connection® helpline on +44 (0) 1244 892434 or email colorcoat.connection@tatasteelurope.com to request support on a broad range of topics including:

- Specification support.
- Building Regulations.
- Energy Efficiency, savings and paybacks.
- Building integrated renewable technologies.
- Responsible sourcing to BES 6001.
- System suitability, durability and guarantees for project specific applications.
- Environmental Product Declarations.
- Structural implications.
- Fire performance.
- Acoustics.
- Sustainability assessment tools such as BREEAM.

Colorcoat® supply chain

Colorcoat® products are available through our market-leading supply chain partners. We recommend their CE-marked systems for the very highest quality and service in the UK and worldwide.

For further details on our supply chain partners in the UK, please visit www.colorcoat-online.com/SCP

www.colorcoat-online.com

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