



Gamesa technological solutions

for regions with icy conditions

C/ Ciudad de la Innovación, 9-11
31621 Sarriguren (Spain)
Tel: +34 948 771 000
Fax: +34 948 165 039
info@gamesacorp.com
www.gamesacorp.com

AUSTRALIA
Level 39 , 385 Bourke Street
Melbourne VIC 3000

BRAZIL
Eldorado Business Tower
Av. das Nações Unidas, 8.501 15º andar
Pinheiros, São Paulo - SP
Tel: +55 11 3096 4444

CHILE
Presidente Riesco 5335 - Piso 9
Las Condes - Santiago
Tel: +56 (2) 2714 3872

CHINA
23/F, Tower 1,
Beijing Prosper Center No. 5
Guanghua Road,
Chaoyang District,
Beijing 100020
Tel: +86 10 5789 0899
Fax: +86 10 5761 1996

EGYPT
3, Rd 218 Degla
11431 Maadi,
Cairo
Tel: +20 225 211 048
Fax: +20 225 211 282

FRANCE
97 Allée Borodine - Cedre 3
69800 Saint Priest
Tel: +33 (0) 4 72 79 49 39

GERMANY
Röntgenstraße 28
22335 Hamburg Fuhlsbüttel
Tel: +49 40 537 998 440

GREECE
9 Adrianou str,
11525 Neo Psychiko,
Athens
Tel: +30 21067 53300
Fax: +30 21067 53305

HONG KONG
Asia Pacific Oceania
Central Plaza, 35th Floor
18, Harbour Road
Hong Kong SAR
Tel: +852 2593 1140

INDIA
The Futura IT Park, B-Block, 8th Floor
334, Rajiv Gandhi Salai
Sholinganallur, Chennai - 600 119
Tel: +91 44 3924 2424
sales.india@gamesacorp.com

ITALY
Via Ostiense 131/L
Corpo C1 - 9° piano
00154 Rome
Tel: +39 06 5750531
Fax: +39 06 5754735

JAPAN
TOC Minatomirai Bldg, 10F,
1-1-7 Sakuragi-cho, Naka-ku,
Yokohama-shi,
Kanagawa 231-0062
Tel: +81 80 3465 6861

MEXICO
Torre Mayor
Paseo de la Reforma 505, piso 41
Col. Cuauhtémoc
06500, Ciudad de México
Tel: +52 55 50179700

PHILIPPINES
22th Floor, The Enterprise Center Tower I
1226 Ayala Avenue
Makati City Philippines
Tel: +63 917 820 4414

POLAND
Ul. Galaktyczna 30A
80-299 Gdansk
Tel: +48 58 766 62 62
Fax: +48 58 766 62 99
poland.wind@gamesacorp.com

ROMANIA
169A Calea Floreasca Street,
Building A, 4th Floor,
Office no 2069, Sector 1
014459 Bucarest
Tel: +40 318 21 24
Fax: +40 318 60 21 00

SRI LANKA
#51/1, Colombo Road,
Kurana, Katunayake
Tel: +94 31 2235890

SWEDEN, FINLAND, NORWAY
Biblotekstorget 8
171 45 Solna (Sweden)
Tel: +46 (0) 8 510 668 10

THAILAND
Sathorn Square
98 North Sathorn Road
37/F Sathorn Square
Silom, Bangkok
Bangkok 10500

TURKEY
Astoria, Buyukdere Cad. No. 127
Kule A, Kat 10
Esentepe, Istanbul 34394
Tel: +90 212 340 76 00

UNITED KINGDOM
Braidhurst House
Finch Way,
Strathclyde Business Park,
Bellshill ML4 3PE
Tel: +44 1698 572 860

UNITED STATES
1150 Northbrook Drive
Trevose, PA 19053
Tel: +1 215 710 3100
Fax: +1 267 790 0453



- ▶ **SAFE WIND TURBINE OPERATION IN REGIONS WITH EXTREME COLD WEATHER** where ice may build up on the blade surface.
- ▶ **RECOVERY OF 50% OF THE ANNUAL ENERGY LOST** because of icing*.
- ▶ **LOW POWER CONSUMPTION.**
- ▶ **RELATIVELY LOW CAPEX AND POSITIVE RETURN ON INVESTMENT**, with few days of ice per year in a project with a service life of 20 years.
- ▶ **NO IMPACT ON THE TURBINE'S EFFICIENCY** during normal operating conditions.

** Depending on the specific environmental conditions of the site.*

In order to minimize the environmental impact, this document has been printed on paper made from 50% pure cellulose fiber (ECC), 40% selected pre-consumer recycled fiber, and 10% post-consumer deinked recycled fiber inks based exclusively on vegetable oils with a minimum volatile organic compound (VOC) content. Varnish based predominantly on natural and renewable raw materials.

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Gamesa offers tailor-made solutions that adapt to the site's requirements, while generating minimum losses for the client.

Technological advancement is an essential element of Gamesa's enterprise. With a goal to respond fully to its customers' needs, Gamesa invests heavily in R&D to improve the efficiency and capabilities of its products and services, and to design and manufacture increasingly advanced wind turbines.

Optimizing its technology to ensure the complete satisfaction of its clients is a central focus for Gamesa.

At wind farms built in regions with very cold weather, the risk of ice building up on the blades is very high. This can have a negative and potentially significant impact on the productivity and profitability of the project.

Gamesa offers specific, tailor-made solutions for wind farms facing these conditions that adapt turbine operations to the site's requirements, while generating minimum losses for the client.

The Bladeshield™ coating, the Blade De-icing System (BDS) and the Ice Prevention System (IPS) are three of Gamesa's newest technological developments for projects facing these challenges.

The solutions are ideal for addressing the need to mitigate the impact of icy conditions on wind turbine performance and production and guarantee safe wind turbine operation on the coldest winter days.

Ice Detection System (IDS)

Solution that detects ice build-up on the blade surface and enables the wind turbine to be stopped when considered necessary to maintain safety. The control system processes the information obtained from several sensors located on the wind turbine and analyzes in real time possible efficiency losses that may be associated with the presence of ice on the blade surface. The wind turbine resumes operation when the environmental conditions so permit once the ice has melted naturally.

Bladeshield™

Bladeshield™ is a special hydrophobic coating that is applied onto the surface of the blades, without affecting their aerodynamic and anti-erosion properties. This solution has been widely tested in a laboratory setting as well as validated on commercial wind turbines.

Blade De-icing System (BDS)

The Blade De-icing System (BDS), which is currently available for Gamesa's 2.0-2.5 MW platform models, enables de-icing through the use of air heaters fitted on the blade root. This solution speeds up the natural thawing process, thus reducing turbine downtime. The ice is detected by a 'smart' control system that, once the BDS is activated, forces the flow of hot air through the leading edge and the internal structure of the blade.

The first Blade De-icing System units were fitted on G114-2.0 MW wind turbines at a wind farm in Sweden in 2014.

Ice Prevention System (IPS)

The Ice Prevention System (IPS) combines specific de-icing and anti-icing technologies and was developed in partnership with the VTT Technical Research Center of Finland, an internationally renowned organization with over 20 years' experience in this field.

The system, which is currently available for the Gamesa 5.0 MW platform, consists of incorporating a thermo-resistive carbon fiber mesh in the critical areas of the blade's leading edge during the manufacturing process. At the wind farm, the control system identifies environmental conditions that could cause ice to build up on the blade, and works to prevent icing by activating the thermo-resistive elements integrated into the structure.

Under extreme environmental conditions, when ice formation cannot be prevented, IPS can also operate as a de-icing system. The first prototype of the Ice Prevention System has been fitted at a commercial wind farm in Finland under actual extreme environmental conditions.

