ENVIRONMENTAL PRODUCT DECLARATION

Electricity from:

European GAMESA G132 - 5.0 MW onshore wind farm

Valid until: 05/05/2018

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UN CPC 17, Group 171 - Electrical energy

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CONTENT

ACRONYMS AND ABBREVATIONS

AEP	Annual Energy Production
AP	Acidification Potential
B2B	Business to Business
CoE	Cost of energy
EIS	Environmental Impact Study
EP	Eutrophication Potential
EPD	Environmental Product Declaration
GCT	Gamesa Corporación Tecnológica (GAMESA)
GPI	General Programme Instructions
GWP	Global Warming Potential
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardization
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MW	Megawatt
ODP	Ozone Layer Depletion Potential
PCC	Point of Common Coupling or Point of Common Connection
PCR	Product Category Rules
POCP	Photochemical Ozone Creation Potential
WTG	Wind Turbine Generator

1. INTRODUCTION

1.1. Declared product

This document represents the certified Environmental Product Declaration (EPD) of the electricity generated through an onshore wind farm of GAMESA G132 - 5.0 MW wind turbine generators, located in a European scenario and operating under medium wind conditions (IEC IIA), and then distributed to a European customer connected to 132 kV.

GAMESA is dedicated to both the design and the manufacturing of its wind turbines as well as to the installation and assembly of the final product at the wind farm. Therefore, the company is fully aware of the entire life cycle of their products.

The functional unit, to which all outcomes are referred to is:

" 1 kWh of electricity generated through an onshore wind farm of GAMESA G132 - 5.0 MW wind turbine generators, located in a European scenario and operating under medium wind conditions (IEC IIA) and thereafter distributed to a European customer connected to 132 kV "

Wind energy is the most reliable and effective renewable energy to meet the growing energy demand, with the foreseeable depletion of the non-renewable traditional energy resources. Furthermore, it is a guarantee of competitiveness, because in most countries is responsible for the lowering price of the energy pool.

Although having common features with other renewable energy sources - avoids CO_2 emissions, it's an inexhaustible resource and reduces the energy vulnerability of countries - its industrial character and maturity, with a developed technological learning curve, allows achieving very competitive market prices.

Wind energy will be the leading technology in transforming the global energy supply structure towards a truly sustainable energy future based on indigenous, non-polluting and competitive renewable technologies.

1.2. Environmental declaration and the EPD System

An environmental product declaration is defined in ISO 14025 as the quantification of environmental data for a product with categories and parameters specified in the ISO 14040 standard series, but not excluding additional environmental information.

The International EPD® System has as main goal, the ambition to help and support organizations to communicate the environmental performance of their products (goods and services) in a credible and understandable manner.

Therefore, it offers a complete program for any organization interested in developing and communicating EPDs according to ISO 14025, also supporting other EPD programmes (i.e. national, sectoral, etc.) in seeking cooperation and harmonization and helping organizations to broaden the use of environmental claims on the international market.

Environmental Product Declarations (EPDs) add a new dimension to the market, offering information on the environmental performance of products and services. The use of EPDs, leads to a number of benefits for organizations that develop declarations of their own products as well as for those who make use of the information contained in these Environmental Product Declarations.

This EPD has been made in accordance with the standards of the International EPD Consortium. EPD is a system for international use of Type III environmental declarations, according to ISO 14025. The International EPD® System and its applications are described in the General Program Instructions.

The documents on which this EPD is based are, in order of relevance the following ones:

- Product Category Rules according to ISO 14025:2006, PCR 2007:08 version 3.0 UN CPC 171 & 173: Electricity, Steam, and Hot/Cold Water Generation and Distribution.
- General Programme Instructions for Environmental Product Declarations, Version 2.01 (currently under revision and being updated to version 2.5).
- ISO 14025 - Type III Environmental Declarations.
- ISO 14040/44 on Life Cycle Assessment (LCA).

This EPD contains an LCA-based environmental performance statement. It also contains additional environmental information, in accordance with the corresponding PCR:

- Information on the impact on biodiversity
- Information on land use classification based on CORINE land uses
- Information on environmental hazards
- Information on the electromagnetic fields generated
- Information on product noise
- Information about the visual impact of the wind farm

1.3. GAMESA, LCA and EPD

GAMESA (Gamesa Corporación Tecnológica - GCT) as a designer of renewable energy commodities considers that is essential to know the main environmental impacts of its products, which are lower than those generated by traditional energy sources. Despite this, the company is aware that there is still environmental improvement potential in our products and that those environmental impacts can be further minimized through an optimized design.

The tool used for reducing these impacts is the detailed analysis of the product life cycle. Using the Life Cycle Assessment methodology (LCA) we can identify the environmental impacts of our products from the extraction of raw materials until the end-of-life of the wind turbine. GAMESA analyzes each phase in a project with the goal of eliminating or minimizing the environmental impacts, assuring that these impacts are not transferred between different life cycle phases.

From this starting point, a further step is the certification by an Environmental Product Declaration (EPD) of the energy generated and distributed using GAMESA G132 - 5.0 MW onshore wind turbines, ensuring the reliability of the data entered into the LCA as well as the transparency about the environmental performance of our products.

2. THE COMPANY AND THE PRODUCT

2.1. GAMESA (Gamesa Corporación Tecnológica - GCT)

With over 20 years of experience, GAMESA is a global technology leader in the wind industry. Its comprehensive response in this market includes the design, construction, installation and maintenance of wind turbines, with more than 30,000 MW installed in 45 countries and 19,500 MW under maintenance.

The company has production centers in the main wind markets: Spain and China, as the global production and supply hubs, while maintaining its local production capacity in India, USA, and Brazil. Sales outside Spain accounts for more than 88% of all MW sold in 2013.

GAMESA is also a world leader in the development, construction and sale of wind farms, having installed 6,400 MW and having a portfolio of more than 18,300 MW in Europe, America and Asia.

The annual equivalent of its 30,000 MW installed accounts to more than 6,4 million tons of petroleum equivalents (TEP) per year and prevents the emission into the atmosphere of more than 45 million tonnes of CO_2 per year. GAMESA is within the main international sustainability indexes: FTSE4Good and Ethibel.

The Company is certified to the following management systems:

- ISO 14001:2004 - Environmental management systems
- ISO 14006:2011 - Environmental management systems. Guidelines for incorporating eco-design. Verified eco-designed products:
  - G10X - 4.5 MW Wind Turbine Generator
  - G114 - 2.0 MW Wind Turbine Generator
  - PR - Electrical vehicle charging point
- ISO 14064:2006 - Greenhouse gases (Organization level)
- ISO 9001:2008 - Quality management systems
- OHSAS 18001:2007 - Occupational health and safety management systems

In addition, GAMESA is a founding member of the Basque Ecodesign Center, which mission is to foster the development of ideas and business activities through eco-design, improving competitiveness and preventing damage to the environment in the Basque Country.

2.2. Product system description

The baseline system under study is an average GAMESA onshore wind farm composed of 5.0 MW WTGs, located on a European scenario and operating under medium wind conditions (IEC IIA). The energy is finally distributed to a European customer connected to 132 kV. The average total installed capacity for this kind of wind farms was considered 20 MW, so that the baseline system is assumed to be composed of 4 GAMESA G132 WTGs of 5.0 MW unitary power each with an estimated electricity production of 19,092 MWh/year per WTG (output at WTG). It was considered 2% core losses between the WTG and the electrical grid connection point (or PCC - Point of Common Coupling or Point of Common Connection). This PCC was located 15 km after the wind farm transformer substation (electricity production of 18,710 MWh/year per WTG at PCC). Finally, it was considered 2.2% additional downstream losses for transmitting and distributing the electricity from the PCC to a final European customer connected to 132 kV. The amount of net electricity was 18,299 MWh/year per WTG at the final average European customer connected to 132 kV.

GAMESA is able to supply different kind of towers, seeking a right placement of the rotor at the height which optimizes the energy harvested. In this EPD, 95 meters high steel towers have been considered. All the internal wiring of the wind farm, the transformer substation and the electrical infrastructure needed to reach the connection point of the electrical network (also known as PCC) are inside the system boundaries. The infrastructure needed for electrical transmission and distribution until a final average European customer connected to 132 kV is also included in the present EPD, as well as the inevitable losses that will occur in the electrical transportation stage.

2.2.1. The GAMESA G132 - 5.0 MW Wind Turbine Generator

GAMESA 5.0 MW platform demonstrates that GAMESA has the knowledge, experience, and resources needed to develop wind turbines capable of extracting maximum power from the wind. GAMESA 5.0 MW platform's innovative modular design and technology ensure maximum reliability and meet the most demanding grid connection regulations and the most restrictive environmental standards. GAMESA has applied design and validation concepts to its new wind turbine development that are only comparable to those used in such demanding industries as the aeronautical industry in order to assure product reliability from the first day in operation.

The GAMESA G132 is a 5.0 MW rated power turbine, with a three blade rotor. It has a rotor diameter of 132 m, and a swept area of 13,685 m^2. It is supported by a steel, hybrid or concrete tower of 95, 120 or 140 m. For the present EPD an steel tower of 95 m has been considered. The expected service life of the product is stated in 20 years, without reconsidering GAMESA's life extension program which can significantly enhance this period of time until 30 years of operation.

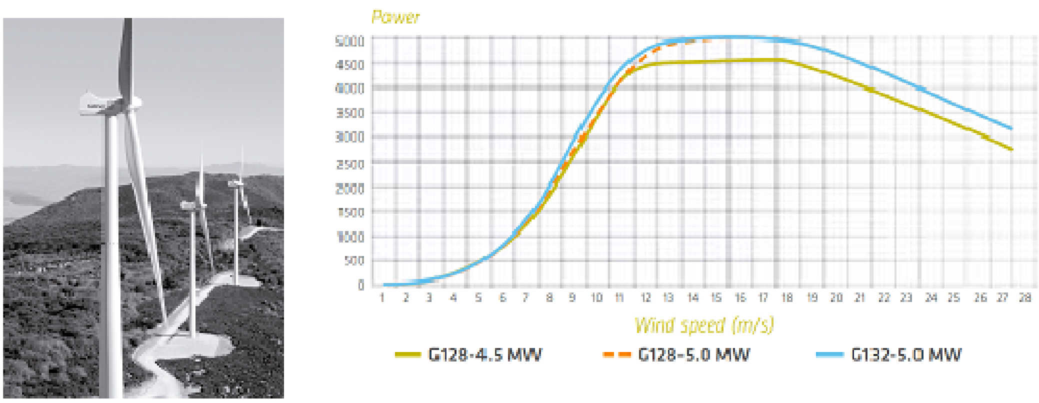

Figure 1.- GAMESA 4.5/5.0 MW power curves

Model	G128-4.5 MW	G128-5.0 MW(1)	G132-5.0 MW(1)	G128-5.0 MW Offshore	G132-5.0 MW Offshore
IEC	IIA	IA /IIA	IIA	IB	S
Rated Power	4,500 kW	5,000 kW	5,000 kW	5,000 kW	5,000 kW
Tower Heights	81, 95, 120, 140 m	81(2), 95, 120, 140 m	95, 120, 140 m	80-94 m + project specific	Project specific
Type Certificate	IEC and DiBT Certificates	In process	In process	IEC Certificate	In process
Env. / Opt.(3)	√	√	√	√	√
50 Hz/60 Hz	√	√	√	√	√
Track Record (installed units as of end 2013)	16	(4)	(5)	1	-

(1) Under development.
(2) Only tower height available for Class I.
(3) Different versions and optional kits are available to adapt machinery to high or low temperatures and saline or dust environments.
(4) First units in 2014.
(5) First units in 2015.

Table 1.- GAMESA 5.0 MW main characteristics

GAMESA 5.0 MW:

Offers superior reliability:

- Nacelle and blades modular design focused on minimizing inactive time.
- Drive train with no high-speed rotating components.
- Exhaustive validation and testing plan, as well as the first operational prototype since 2009.

Complies with similar logistics & construction requirements as those of the GAMESA 2.0-2.5 MW:

- Modular design of the nacelle and blades to optimize transport and logistics.
- The heaviest module weighs less than the weight of a 2-MW nacelle.
- Gamesa FlexiFit®: The add-on crane attaches to nacelle to simplify and expedite assembly and maintenance.

Optimizes cost of energy (CoE):

- Higher production for projects with limited space.
- Optimization of energetical positions.
- Potential savings in project civil works.

Complies with the most demanding grid connection requirements:

- Gamesa GridMate®: Optimal grid connections due to permanent magnet generator technology + full converter.

Complies with environmental regulations:

- Reduced visual impact.
- Noise reduction: Gamesa NRS® system and new aerodynamic blade profile.

	G128-4.5 MW	G128-5.0 MW	G132-5.0 MW	G128-5.0 MW Offshore	G132-5.0 MW Offshore
ROTOR					
Diameter	128 m		132 m	128 m	132 m
Swept area	12,868 m²		13,685 m²	12,868 m²	13,685 m²
BLADES					
Number of blades	3			3	
Length	62.5 m		64.5 m	62.5 m	64.5 m
Material	Organic matrix composite reinforced with fiber glass or carbon fiber			Organic matrix composite reinforced with fiber glass or carbon fiber	
Type	Segmented	Segmented/ One-piece	One-piece	One-piece	
TOWER					
Type	Steel, hybrid or concrete			Steel	
Height	81, 95, 120, 140 m		95, 120, 140 m	80-94 m + project specific	Project specific
GEAR BOX					
Type	2 planetary stages			2 planetary stages	
Ratio	1:37.88	1:41.405		1:41.405	
GENERATOR					
Type	Permanent magnet synchronous generator with independent modules in parallel			Permanent magnet synchronous generator with independent modules in parallel	
Nominal power	4,500 kW	5,000 kW		5,000 kW	
Voltage	690 V AC			690 V AC	
Frequency	50 Hz / 60 Hz			50 Hz / 60 Hz	
Protection class	IP 54			IP 54	
Rotation speed	448 rpm	490 rpm		490 rpm	
Power factor	0.9 CAP - 0.9 IND *			0.9 CAP - 0.9 IND *	

* Power factor at output terminals of the wind turbine on the low voltage side before entering the transformer, at the rated grid voltage.

Table 2.- GAMESA 4.5/5.0 MW platform features

Advantages of the GAMESA 5.0 MW platform:

- Individual pitch and multivariable control minimize weight, loads and noise.
- Sectional blade for easy transport and installation.
- Compact, high-performance drive train reduces mechanical stress.
- Permanent magnet synchronous generator and full converter technology that allow the most demanding grid code requirements to be met.
- Modular design of the nacelle and blades for maximum reliability and easy assembly and maintenance.
- Add-on crane attaches to nacelle for assisting in the assembly and maintenance of the main modules.
- Aerodynamic blade design and the Gamesa NRS® control system minimize noise emissions.
- Gamesa WindNet®: the advanced SCADA technology for online wind farm control and monitoring.
- Gamesa SMP System: system for predictive maintenance.

2.2.2. The wind farm

Since GAMESA started the LCA study, it was found interesting the concept that its results were extrapolated as far as possible to a test case of a European wind farm and not to an specific site. The reason is to make the information extracted from this report useful to a wider audience. To achieve this goal, it has become necessary to make a generic model representative of an European average wind site from the actual data known from GAMESA 5.0 MW or similar wind farms (i.e. GAMESA 4.5 MW) installed and projected.

The differences between the environmental impacts caused by the erection of various wind farms rely primarily on two variables, the location and the size of the site. The location of the wind farm is directly related to the environmental impact caused in the distribution phase. The farther the wind farm is, the more logistics needed. In the LCA the geographical location of an average GAMESA 5.0 MW has been placed in Central-North Europe (i.e. Finland) and with the following transports systems needs from Spain: freight ship (2,000 km) and freight truck (500 km). This location is considered representative of the current and future European situation of GAMESA G132 - 5.0 MW clients.

Furthermore, in a previous LCA of the WTG G90 2.0 MW a sensitivity analysis was made taken into account the environmental effect of installing a park farther or closer to GAMESA’s manufacturing plants. In this study the variability of the impact results depending on the location were analysed considering 4 different locations for wind farms: France, Poland, Italy and Spain (base scenario). It was concluded that the largest impact increase is not more than a 3%. From this, it can be concluded that the location of the wind farm on a European stage, does not impact significantly on the overall impact generated throughout the life cycle.

Regarding the size of the wind farm, we have assigned the average requirement of materials and civil works for each wind turbine installed. Thus, the environmental impact of the construction of the wind farm is referred to each turbine installed and not limited to a particular park size. For the infrastructures shared by different WTGs (i.e. transformer substation, internal wiring, connection infrastructure to the electrical network, road conditioning to allow access to machinery, etc.), an average wind park size of 20 MW installed (4 WTG of 5 MW) has been used as baseline.

Finally, for the data needed to assess the environmental impact related to the civil works of the wind farm, data from an Spanish (Málaga) wind farm (PE Cámara with 4 WTGs GAMESA 4.5 MW, 18 MW installed) has been used. Although the analyzed site is in Spain, the techniques used for the construction are considered representative for a European wind farm case, as stated by experts in civil engineering from GAMESA technical building office.

2.2.3. Electricity transmission and distribution infrastructure

Once the wind is converted into electricity by the G132 wind turbine generator, the energy is delivered to a final average European consumer (connected to 132 kV) through the electrical transmission and distribution network.

The WTG generates low voltage electricity (690 V). This voltage is increased in the transformer located inside the nacelle reaching medium voltage level to minimize electricity losses (33 kV). At the exit of the wind farm there is another transformer substation allowing the delivery of high voltage electricity to the general network at the PCC (132 kV), 15 km far from the substation. It was considered 2% core losses between the WTG and the electrical grid connection point (PCC). Finally, a

2.2% additional loses were considered during the transmission and distribution of energy from the PCC till an average European customer connected to 132 kV.

It should also be noted that GAMESA is not a company dedicated to the energy distribution business. Instead, it's dedicated to the manufacture of wind turbines, so that the environmental impacts of this stage are inside the wind energy life cycle, but outside of the direct range of GAMESA's activities. The data required for modelling this concrete stage are external to the company, so that have been based on studies and statistics taken by other sources.

2.2.4. Wind energy life cycle

The following figure encompasses the full cradle-to-grave life cycle of the energy generated through a wind farm.

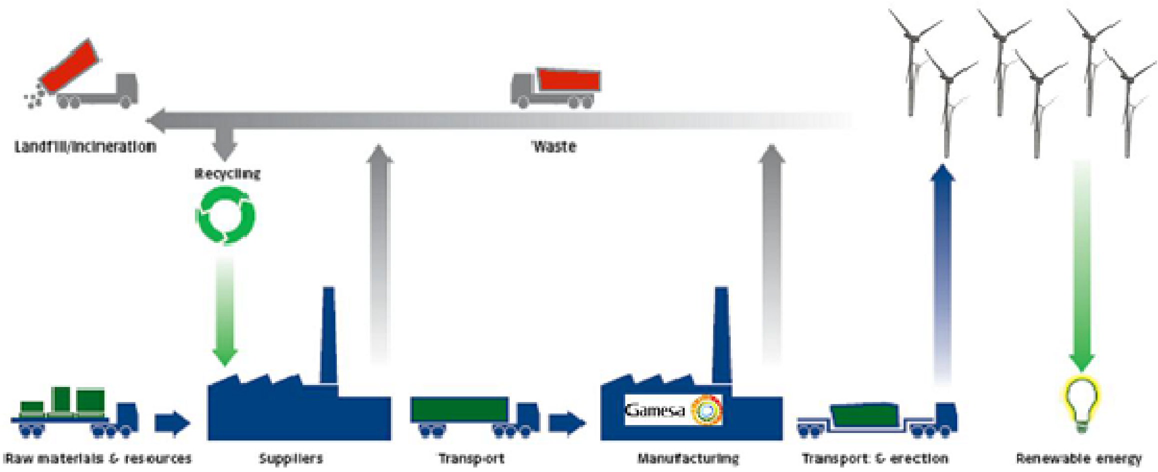

Figure 2 .- Wind energy life cycle

The main environmental impacts of the generated energy are related to the manufacturing of the different components of the wind turbine and the construction of the wind farm. All the steps in this diagram have been taken into account for the assessment. Following the recommendations of the PCR, the energy life cycle has been divided into three main modules: upstream module, core module and downstream module. The concepts included in each of these modules are summarized in the following paragraphs.

2.2.4.1. Core module

The core phase encompasses all the steps related to the construction, operation and decommissioning of the wind farm from the cradle to the grave. This comprehends all the stages from the extraction of the raw materials needed to build the WTG and the wind farm, until the dismantling of the wind farm, including the proper management of the generated waste and the recycled components as well as their corresponding end-of-life treatments.

This module also refers to the manufacturing processes of the WTG performed by GAMESA plants and its suppliers. Besides, the required maintenance of the machinery during its service life is included, both preventive and corrective actions (estimated component replacements and repairs, operating waste management, etc.). All the environmental impacts arising from the logistics related to the previously mentioned concepts are part of the core module too.

Finally, the core also contains a vital part of the wind turbine life cycle, which is the G132 machine's technical performance. Factors such as the annual energy production, the availability of the machine, the electrical losses during operation or the energy self consumption of the turbine for its auxiliary systems, have a decisive influence on the environmental impact of the declared unit.

Figure 3. – GAMESA G132 - 5.0 MW

2.2.4.2. Upstream module

The upstream module considered in this study, includes the environmental impacts related to the production of all necessary ancillary substances for the proper operation of the wind farm during the 20 years of service life. Since this kind of electricity generation system doesn't require any fuel, this module mainly includes the required quantities of hydraulic oil, lubricating oils and greases, as well as the emissions arising from the transport of these substances from the suppliers to the wind farm.

2.2.4.3. Downstream module

The downstream stage comprises all the impacts that happen from the moment when the energy is delivered to the electricity network, leaving this way the wind farm at the PCC, until it reaches a final average European customer connected to 132 kV. Thus, for this stage it is necessary to consider the electrical network required for the energy transportation, but also the inherent losses during the electrical transmission and distribution.

3. ENVIRONMENTAL PERFORMANCE BASED ON LCA

3.1. Life Cycle Assessment methodology

As stated in ISO 14025:2010 (Environmental labels and declarations - Type III environmental declarations - Principles and procedures), the environmental impact data outlined in an Environmental Product Declaration EPD, are part of the results obtained from an analysis following the Life Cycle Assessment (LCA) methodology.

The LCA methodology, which has been followed when conducting this study is a procedure based on the international standards ISO 14040, ISO 14044 and the Product Category Rules for UN CPC 171.

With the use of the LCA method we are able to obtain a complete breakdown of the elementary inputs and outputs which compose our product system along its whole life cycle. These inputs and outputs are given in the form of raw material consumptions or as different kind of emissions, and are the indicators showing the real interaction of the analyzed product with nature.

Besides, the LCA methodology also allows us to obtain global results associated to different environmental impact categories such as global warming potential, acidification potential, eutrophication potential or photochemical ozone creation potential, if we apply different characterization methods.

The LCA only quantifies information on environmental impacts, leaving apart social and economic indicators. In the same way, some environmental impacts associated with the product life cycle as land use, impacts on biodiversity, electromagnetic fields, noise, visual impact or accidental risks cannot be identified from the LCA perspective. For this reason, these environmental impacts will be individually analyzed in section 4 of this EPD (“Additional environmental impacts”).

3.2. System boundaries and data sources

This Environmental Product Declaration (EPD) reflects the life cycle impact of the electricity generated through an onshore wind farm of GAMESA G132 - 5.0 MW wind turbine generators, located on a European scenario and operating under medium wind conditions (IEC IIA) and thereafter distributed to an average European customer connected to 132 kV.

The following figure provides a simplified representation of the boundaries of the studied system, decomposing the life cycle on different modules, as required by the PCR.

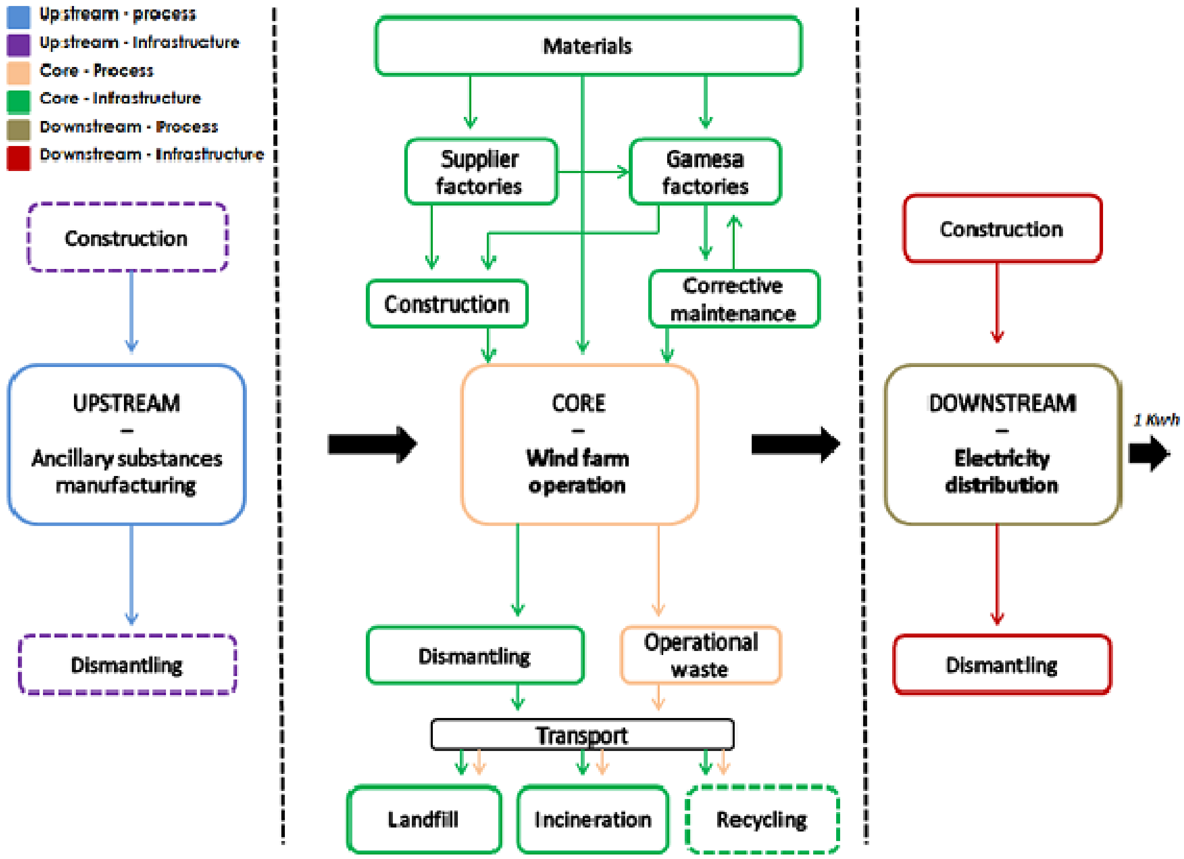

Figure 4. - System boundaries

The blocks in the graph above whose boundary is a dashed line, have not been taken into account in the LCA, as permitted by the PCR. The arrows represent the different transports of materials, parts or bigger components.

The data used to create the models of the life cycle phases described in the above diagram, have been obtained mainly directly from GAMESA and from its suppliers. These data are fully traceable and are the basis for ensuring that the results of the LCA correspond to the reality of the product.

As a baseline, all the data for which GAMESA has direct access to, have been included in the analysis seeking the best data completeness. However, given the complexity of the LCI of a wind turbine and a wind farm, it is difficult to collect exactly the 100% of the real data/information, data can be over or underestimated. The objective pursued in this study was to include at least the 99% of the total mass and energy inputs in the life cycle of the WTG, and consequently that the sum of all the inputs not taken into account for the study were less than 1%. It was finally analyzed in this study a 99,86% of the initially estimated weight. This value is an accurate reflection of reality, very representative and comprehensive. In addition, all the energy flows incurred in GAMESA manufacturing plants have also been included in the analysis.

From this primary data, when creating the life cycle model of the analyzed system the Ecoinvent 3.1 LCIs database has been used (SM: cut-off). This database contains international industrial life cycle inventory data on energy supply, resource extraction, material supply, chemicals, metals, agriculture, waste management services, and transport services. Ecoinvent can be considered nowadays on of the main world's leading supplier of consistent and transparent life cycle inventory (LCI) data.

All the data used to create the life cycle model of the electricity generated by an onshore GAMESA G132 - 5.0 MW wind farm, reflect the technology currently used and planned by GAMESA and are considered representative for the period of validity of this EPD. The G132 - 5 MW is a new machine and consequently there is no statistical data on some phases, for example, on G132 dismantling. In those cases, data from similar wind farms have been used (i.e. PE Cámara 18 MW, Málaga - Spain).

3.2.1. Core - Infrastructure

Data on the materials needed for construction and subsequent decommissioning of each GAMESA G132 - 5.0 MW WTG represent the technology currently used or planned by GAMESA for this new turbine model or are based on available data for similar ones (i.e. GAMESA 4.5 MW).

It can be considered that the data will still be representative during the period that no significant technological changes occur in the functionality or in the manufacturing processes of the major components such as: wind turbine tower, foundation, gearbox, generator or wind turbine rotor.

Data on the materials needed for the construction and decommissioning of the wind farm, the transformer substation, the internal wiring of the wind farm and the network (15 km) till the connection point of the electrical grid (PCC), were obtained from similar wind farms already installed by GAMESA (i.e. PE Cámara 18 MW, Málaga - Spain). The EPD verifier had access to more comprehensive information on the data used for this simulation. This data is representative of the technology currently used by GAMESA, as long as new construction methods are not developed.

GAMESA is responsible for the manufacturing of most of the major components of the WTG. Data on GAMESA production processes have been obtained from measurements and records obtained in the own GAMESA manufacturing plants for the year 2013 and partially for the year 2014. These data are based on the technology currently used by GAMESA, and are considered representative as long as the same manufacturing technologies are used. The data for the electricity mix of the energy consumed by GAMESA manufacturing facilities is representative of the Spanish electricity mix expected for the year 2014, according to Ecoinvent v3.1 (System model: cut-off).

In the case of an onshore GAMESA G132 - 5.0 MW WTG delivered to a European customer, the factories involved in the manufacturing of the WTG are the ones collected in the following table. All these manufacturing plants have been individually assessed for the purpose of the study:

MANUFACTURING PLANT	LOCATION	ACTIVITY
Montajes Eólicos Tauste	Tauste (Zaragoza - Spain)	Nacelle and rotor assembly
GAMESA Cantarey	Reinosa (Cantabria - Spain)	Generator manufacture
GAMESA Aoiz	Aoiz (Navarra - Spain)	Blade manufacture
GET ECHESA Asteasu	Asteasu (Guipuzcoa - Spain)	Gearbox parts machining
GET TRELSA Lerma	Lerma (Burgos - Spain)	Gearbox assembly
FNN Burgos	Burgos (Burgos - Spain)	HUB manufacture
Enertron	Coslada (Madrid - Spain)	Converter manufacture
Valencia Power Converters	Benissanó (Valencia - Spain)	Production and assembly of cabinets

Table 3.- GAMESA manufacturing plants

The manufacturing processes of relevant components supplied directly to GAMESA (e.g. transformer, low speed shaft, etc.) have been simulated by assimilating and correlating those components to other available and studied processes/components and by using Ecoinvent 3.1 process/LCI data.

All the G132 wind turbine components are designed to have a service life equal to or greater than the turbine itself. However, sometimes the WTG is exposed to situations that differ from the normal design operation, that can reduce the expected lifetime of a component or even disable it. Seeking to have a good overview of the environmental impact caused by these unexpected failures and the need for replacement of components, the impact of performing corrective maintenance actions on GAMESA G132 - 5.0 MW machines has been also simulated in the LCA which supports this EPD. Data on failure rate statistics have been taken directly from internal studies made by GAMESA.

After 20 years of service life, the WTG reaches its end-of-life phase. In this phase, the whole WTG and the wind farm are dismantled and the wastes generated are properly managed. For this stage, the following destinations have been assumed.

- The tower, hub, shaft, gearbox, frames and all metals are recovered for recycling (95%).
- Electrical and electronic elements are recovered (90% rate for cables and 75 % for other electrical and electronic components). For the analysis, all the electrical and electronic components are supposed to be managed through a WEEE sorting plant.
- Fluids as the gearbox oils, hydraulic oil circuits, are segregated for delivery to authorized recycling plants for specialized treatment.
- The 33.3% of the polymers are recycled. The other 66.6% ends in a landfill (33.3%) and in incineration treatments (33.3%).
- Wind turbine waste without a recycling destination, which mainly include the blades, the concrete of the towers and the foundation (upper part), are sent to a landfill.

Since the GAMESA G132 - 5.0 MW is a new machine, there is no statistical data on G132 wind farms dismantling. For data concerning the dismantling and end-of-life of the product, the information and data from the wind farm “Cámara” in Málaga – Spain (18 MW, 4 WTGs 4.5 MW) has been considered. This information is considered representative of current situation of decommissioning of wind turbines. In order to achieve the wind farm land restoration, reached the decommissioning moment GAMESA follows the following steps:

1. Removal of the structure of the wind turbine
2. Demolition of foundation (upper part) and transmission network
3. Demolition of substation, road access and platforms
4. Vegetal cover surface treatment
5. Seeding and planting, landscape recovery
6. Recycling of wind turbine components
7. Waste treatment and disposal

3.2.2. Core - Process

All the environmental impacts associated with the operation of the wind farm, given its 20 years of life, have been taken into account in this module. One of the main advantages of the wind energy over other non-renewable sources of energy is its independence on fossil fuels. This environmental benefit is reflected at this stage when we look at the results.

In the core-process module we have considered the following concepts:

- Preventive maintenance required during the lifespan of the wind farm (1% of complete WTG manufacturing, transportation and end-of-life management).
- The proper waste management of consumable needed during operation of the wind farm (i.e. oils), including its transportation to the authorized recycling plants for specialized treatment.
- In-service SF6 leakage from circuit breakers of substation (0.5% per annum + 1% maintenance).

The data used in the LCA on the technical performance of the system during its operational phase, have been obtained from internal documents of GAMESA. This includes aspects such as annual energy generation (electricity production of 19,092 MWh/year per WTG, as output at the WTG), machine availability, energy losses (2% core losses from WTG till PCC), maintenance protocols, etc. These data reflect the technologies currently used by GAMESA and are considered representative as long as no substantial technical changes are introduced in the performance of the machine during operation and maintenance phase.

3.2.3. Upstream

Since wind power requires no fuel for equipment operation, the upstream module includes the production of auxiliary substances that are necessary for the operation of the energy conversion plant. Therefore, in this section the following concepts have been taken into account:

- Production of the necessary quantities of hydraulic oil, lubricating oils and fat by GAMESA suppliers.
- All the transport associated with the need to carry these maintenance supplies from the suppliers till the wind farm.

The replacements of lubricating oil, hydraulic oil and fat due to maintenance were obtained from the lubrication charts and from the maintenance manual of the G132 WTG. These documents nowadays specify the maintenance needs of this equipment and are considered representative provided that no substantial variations related to the maintenance of the wind turbine occur.

The infrastructure and the equipment of the suppliers of the auxiliary substances necessary for the operation of the wind farm have been excluded from the analysis, as allowed by the PCR.

3.2.4. Downstream

The downstream module represents mainly two different environmental impacts. The first one is the impact related to the electrical grid, which is considered within the sub-module “downstream infrastructure”. An estimated value of $6{,}7 \times 10^{-9}$ km of electricity transmission network (high voltage) per kWh was considered based on average Spanish and European values and values already considered in a previous EPD (GAMESA WTG G90 2.0 MW). The data used for simulating the electrical network was obtained from the Ecoinvent 3.1 database.

The second impact is related to the electrical losses inherent to the transmission and distribution of generated electricity from the electrical grid connection point (or PCC - Point of Common Coupling or Point of Common Connection) till an average European consumer connected to 132 kV, which are considered in the sub-module “downstream process”.

Due to the difficulties of GAMESA to separate the energy delivered to each type of customer at European level, the average value of 2.2% has been considered for the electrical losses in the "downstream process". This means that 2.2% of every injected kWh at PCC is lost in the transmission and distribution network before arriving to an average European customer connected to 132 kV.

3.3. Eco-profile

In the following table, it is shown the environmental performance of the GAMESA G132 - 5.0 MW onshore wind turbine from a life cycle perspective, in the separated phases that were described above. The EPD verifier had access to more comprehensive information on the LCA which supports this declaration.

The functional unit, to which all outcomes are referred to is:

" 1 kWh of electricity generated through an onshore wind farm of GAMESA G132 - 5.0 MW wind turbine generators, located in a European scenario and operating under medium wind conditions (IEC IIA) and thereafter distributed to a European customer connected to 132 kV "

3.3.1. Scenario: IEC II Wind class - Wind Farm - 95 m steel tower

ECOPROFILE	Scenario: IEC II Wind class - European Wind Farm - 95 m steel tower							
USE OF RESOURCES	1 kWh electricity generated and distributed							
	UNIT	Upstream	Core process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Non-renewable material resources								
Gravel, in ground	g	2,19E-03	9,38E-03	1,86E+01	**1,86E+01**	4,09E-01	2,15E+00	**2,11E+01**
Calcite, in ground	g	3,94E-04	4,89E-03	1,15E+00	**1,15E+00**	2,53E-02	3,99E-01	**1,58E+00**
Iron, 46% in ore, 25% in crude ore, in ground	g	2,87E-04	1,07E-02	1,59E+00	**1,60E+00**	3,53E-02	6,74E-02	**1,71E+00**
Gangue, bauxite, in ground	g	2,21E-04	2,39E-03	9,12E-01	**9,15E-01**	2,01E-02	3,66E-01	**1,30E+00**
Clay, unspecified, in ground	g	4,13E-04	7,92E-04	2,94E-01	**2,95E-01**	6,49E-03	1,48E-01	**4,50E-01**
Sodium chloride, in ground	g	1,83E-05	1,21E-03	1,57E-01	**1,58E-01**	3,48E-03	1,99E-03	**1,64E-01**
Aluminium, in ground	g	2,06E-05	2,22E-04	8,48E-02	**8,50E-02**	1,87E-03	3,40E-02	**1,21E-01**
Metamorphous rock, graphite containing, in ground	g	1,62E-08	2,73E-06	3,25E-04	**3,28E-04**	7,22E-06	2,75E-05	**3,63E-04**
Nickel, 1.98% in silicates, 1.04% in crude ore, in ground	g	2,18E-05	5,70E-04	7,19E-02	**7,24E-02**	1,59E-03	8,43E-04	**7,49E-02**
Colemanite, in ground	g	5,87E-08	3,59E-04	4,57E-02	**4,61E-02**	1,01E-03	7,24E-07	**4,71E-02**
Other non-renewable resources[1]	g	1,79E-04	1,25E-03	1,88E-01	**1,89E-01**	4,17E-03	1,66E-02	**2,10E-01**
Renewable material resources								
Wood[2]	g	6,41E-04	1,63E-03	2,59E-01	**2,61E-01**	5,75E-03	2,36E-02	**2,91E-01**
Water use								
Freshwater	m^3	6,09E-08	1,43E-07	2,30E-05	**2,32E-05**	5,10E-07	1,83E-06	**2,55E-05**
Saltwater	m^3	2,52E-08	1,18E-08	2,30E-06	**2,34E-06**	5,15E-08	2,96E-07	**2,69E-06**
Water, unspecified	m^3	4,97E-05	2,29E-04	3,44E-02	**3,47E-02**	7,63E-04	2,76E-03	**3,82E-02**
Water used directly by the core process	m^3	-	-	-	**-**	-	-	**-**
Total water	m^3	4,98E-05	2,30E-04	3,44E-02	**3,47E-02**	7,63E-04	2,76E-03	**3,82E-02**
Non-renewable energy resources								
Crude oil	g	2,95E-02	3,58E-03	8,36E-01	**8,69E-01**	1,91E-02	5,42E-02	**9,42E-01**
Hard coal	g	2,70E-03	1,21E-02	1,93E+00	**1,95E+00**	4,28E-02	1,74E-01	**2,16E+00**
Brown coal	g	6,70E-04	1,19E-03	1,85E-01	**1,87E-01**	4,12E-03	1,60E-02	**2,07E-01**
Natural gas[3]	g	1,71E+00	3,05E+00	4,38E+02	**4,42E+02**	9,73E+00	1,59E+01	**4,68E+02**
Uranium	g	4,43E-08	5,55E-06	5,60E-04	**5,66E-04**	1,24E-05	4,89E-07	**5,79E-04**
Uranium[4]	MJ	4,74E-09	5,94E-07	5,99E-05	**6,05E-05**	1,33E-06	5,23E-08	**6,19E-05**
Peat	g	9,41E-06	1,42E-05	2,00E-03	**2,03E-03**	4,46E-05	5,88E-05	**2,13E-03**
Renewable energy resources								
Energy from hydropower	MJ	7,62E-06	2,72E-05	4,33E-03	**4,37E-03**	9,60E-05	4,54E-04	**4,92E-03**
Energy from biomass	MJ	4,32E-06	1,22E-05	1,90E-03	**1,91E-03**	4,21E-05	1,55E-04	**2,11E-03**
Wind electricity	MJ	6,82E-07	4,34E-06	6,14E-04	**6,19E-04**	1,36E-05	5,46E-06	**6,38E-04**
Solar electricity	MJ	3,22E-09	1,73E-09	5,27E-07	**5,32E-07**	1,17E-08	2,02E-08	**5,64E-07**
Geothermal energy	MJ	8,57E-07	1,35E-06	1,96E-04	**1,98E-04**	4,35E-06	9,31E-06	**2,11E-04**
Electricity use in wind farm[5]	kWh	-	1,13E-02	-	**1,13E-02**	2,49E-04	-	**1,16E-02**

[1] Sum of 122 substances
[2] Considering an average real density of 1,560 kg/m^3
[3] Considering an average density of 554 kg/m^3
[4] Considering an average conversion of 1 kg uranium = 107 MJ
[5] The electricity used in the wind farm is generated by the wind turbines itself. This electricity has been discounted in net production.

ECOPROFILE	Scenario: IEC II Wind class - European Wind Farm - 95 m steel tower							
USE OF RESOURCES	1 kWh electricity generated and distributed							
	UNIT	Upstream	Core process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Recycled material resources[6]								
Aluminium	g	-	-	2,46E-02	**2,46E-02**	5,41E-04	2,10E-02	**4,61E-02**
Copper	g	-	-	1,44E-02	**1,44E-02**	3,16E-04	1,79E-03	**1,65E-02**
Steel	g	-	-	5,94E-01	**5,94E-01**	1,31E-02	5,31E-02	**6,60E-01**

ECOPROFILE	Scenario: IEC II Wind class - European Wind Farm - 95 m steel tower							
POLLUTANT EMISSIONS	1 kWh electricity generated and distributed							
	UNIT	Upstream	Core process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Potential environmental impacts								
Acidifying gases	g SO_2 eq.	1,85E-04	3,31E-04	5,85E-02	**5,90E-02**	1,30E-03	5,42E-03	**6,57E-02**
Eutrophying substances	g PO_4 eq.	3,21E-05	1,53E-04	2,38E-02	**2,40E-02**	5,28E-04	1,50E-03	**2,60E-02**
Global warming potential (100 y)	g CO_2 eq.	2,28E-02	7,88E-02	8,47E+00	**8,58E+00**	1,89E-01	8,44E-01	**9,61E+00**
Ozone depleting potential (20 y)[7]	g CFC-11 eq.	1,55E-08	4,25E-09	7,85E-07	**8,05E-07**	1,77E-08	4,68E-08	**8,69E-07**
Formation of ground level ozone	g C_2H_4 eq.	1,09E-05	2,32E-05	3,81E-03	**3,84E-03**	8,46E-05	3,16E-04	**4,24E-03**
Emissions to air contributing most to the environmental impact categories[8]								
Ammonia	g	4,84E-07	3,00E-06	4,78E-04	**4,82E-04**	1,06E-05	3,74E-05	**5,30E-04**
Benzene	g	3,32E-07	3,01E-06	4,52E-04	**4,55E-04**	1,00E-05	2,09E-05	**4,86E-04**
Butane	g	1,78E-06	2,93E-07	6,13E-05	**6,33E-05**	1,39E-06	3,99E-06	**6,87E-05**
Carbon dioxide, fossil	g	2,06E-02	4,29E-02	7,63E+00	**7,70E+00**	1,69E-01	7,70E-01	**8,64E+00**
Carbon monoxide, fossil	g	3,11E-05	3,74E-04	6,00E-02	**6,04E-02**	1,33E-03	4,24E-03	**6,59E-02**
Dinitrogen monoxide	g	5,56E-07	1,47E-06	2,32E-04	**2,34E-04**	5,16E-06	1,26E-05	**2,52E-04**
Ethane	g	8,36E-07	1,62E-06	2,45E-04	**2,47E-04**	5,44E-06	1,14E-05	**2,64E-04**
Ethene	g	9,80E-08	1,03E-07	1,73E-05	**1,75E-05**	3,84E-07	1,45E-06	**1,93E-05**
Hexane	g	8,80E-07	2,56E-07	4,43E-05	**4,54E-05**	1,00E-06	2,09E-06	**4,85E-05**
Hydrogen chloride	g	1,41E-06	3,86E-06	6,44E-04	**6,49E-04**	1,43E-05	7,63E-05	**7,40E-04**
Hydrogen fluoride	g	1,83E-07	1,09E-06	2,59E-04	**2,60E-04**	5,73E-06	7,07E-05	**3,37E-04**
Methane, bromochlorodifluoro-, Halon 1211	g	3,45E-11	1,13E-10	1,64E-08	**1,66E-08**	3,65E-10	7,23E-10	**1,77E-08**
Methane, bromotrifluoro-, Halon 1301	g	1,44E-09	1,67E-10	3,96E-08	**4,12E-08**	9,07E-10	2,80E-09	**4,49E-08**
Methane, chlorodifluoro-, HCFC-22	g	3,91E-10	8,90E-09	1,32E-06	**1,33E-06**	2,93E-08	5,75E-08	**1,42E-06**
Methane, fossil	g	7,79E-05	1,52E-04	2,41E-02	**2,43E-02**	5,36E-04	1,97E-03	**2,69E-02**
Methane, tetrachloro-, R-10	g	1,62E-11	1,83E-10	2,70E-08	**2,72E-08**	5,98E-10	2,22E-09	**3,00E-08**
Nitrogen oxides	g	6,61E-05	1,48E-04	2,89E-02	**2,91E-02**	6,40E-04	2,30E-03	**3,20E-02**
Pentane	g	2,21E-06	3,58E-07	7,65E-05	**7,91E-05**	1,74E-06	5,38E-06	**8,62E-05**
Sulfur dioxide	g	1,36E-04	2,16E-04	3,63E-02	**3,66E-02**	8,06E-04	3,56E-03	**4,10E-02**
Sulfur hexafluoride	g	7,47E-08	1,52E-06	2,49E-05	**2,65E-05**	5,84E-07	8,56E-07	**2,80E-05**
Toluene	g	3,22E-07	1,87E-07	3,26E-05	**3,31E-05**	7,29E-07	3,25E-06	**3,71E-05**

[6] Considering 45% of recycled material
[7] Additional (optional) indicator
[8] Emissions contributing in more than a 0.5% in any of the 5 potential environmental impacts assessed.

ECOPROFILE	Scenario: IEC II Wind class - European Wind Farm - 95 m steel tower							
POLLUTANT EMISSIONS	1 kWh electricity generated and distributed							
	UNIT	Upstream	Core process	Core Infrastructure	**TOTAL GENERATED**	Downstream Process	Downstream Infrastructure	**TOTAL DISTRIBUTED**
Emissions to water contributing most to the environmental impact categories[9]								
COD, Chemical Oxygen Demand	g	3,04E-04	1,81E-04	2,87E-02	**2,92E-02**	6,42E-04	1,81E-03	**3,16E-02**
Nitrate	g	5,12E-06	3,75E-05	5,71E-03	**5,75E-03**	1,27E-04	3,51E-04	**6,23E-03**
Phosphate	g	1,61E-05	1,26E-04	1,89E-02	**1,91E-02**	4,20E-04	1,13E-03	**2,06E-02**
Emissions of radioactive isotopes								
C-14	kBq	6,37E-07	1,80E-07	3,29E-05	**3,37E-05**	7,41E-07	1,64E-06	**3,61E-05**
Rn-222	kBq	1,44E-03	3,21E-03	4,75E-01	**4,80E-01**	1,06E-02	1,54E-02	**5,06E-01**
Kr-85	kBq	1,43E-08	4,41E-07	4,52E-05	**4,57E-05**	1,00E-06	1,67E-07	**4,68E-05**
Emissions of biogenic carbon dioxide								
Carbon dioxide, biogenic	g	3,78E-04	8,11E-04	1,34E-01	**1,35E-01**	2,98E-03	1,54E-02	**1,54E-01**
Emissions of toxic substances[10]								
Particulates, < 2.5 um	g	9,52E-06	4,40E-05	7,10E-03	**7,15E-03**	1,57E-04	4,69E-04	**7,78E-03**
Particulates, > 2.5 um, and < 10um	g	2,80E-06	5,13E-05	7,73E-03	**7,78E-03**	1,71E-04	3,58E-04	**8,31E-03**
Particulates, > 10 um	g	1,18E-05	2,07E-04	3,88E-02	**3,90E-02**	8,58E-04	4,65E-03	**4,45E-02**
Chromium VI to air	g	8,34E-10	1,91E-08	2,35E-06	**2,37E-06**	5,22E-08	1,38E-08	**2,44E-06**
Arsenic to air	g	6,60E-09	9,47E-08	1,51E-05	**1,52E-05**	3,35E-07	8,59E-07	**1,64E-05**
PAH, polycyclic aromatic hydrocarbons to air	g	2,33E-09	2,40E-08	5,35E-06	**5,38E-06**	1,18E-07	1,15E-06	**6,64E-06**
Nickel to air	g	2,78E-08	1,76E-07	2,90E-05	**2,92E-05**	6,42E-07	1,89E-06	**3,17E-05**
Benzene to air	g	3,32E-07	3,01E-06	4,52E-04	**4,55E-04**	1,00E-05	2,09E-05	**4,86E-04**
Copper to air	g	2,64E-08	2,88E-07	5,63E-05	**5,66E-05**	1,25E-06	3,11E-06	**6,10E-05**
PAH, polycyclic aromatic hydrocarbons to water	g	8,42E-09	7,33E-09	9,93E-07	**1,01E-06**	2,22E-08	2,59E-08	**1,06E-06**
Cadmium to air	g	2,94E-09	3,10E-08	5,01E-06	**5,05E-06**	1,11E-07	2,92E-07	**5,45E-06**
Emissions of oil to water and ground								
Oils to soil	g	9,50E-05	9,94E-06	2,45E-03	**2,55E-03**	5,62E-05	1,72E-04	**2,78E-03**
Oils to water	g	8,93E-05	9,67E-06	2,40E-03	**2,50E-03**	5,51E-05	2,01E-04	**2,76E-03**

[9] Emissions contributing in more than a 0.5% in any of the 5 potential environmental impacts assessed.
[10] Emission of toxic substances that contribute in more than a 0.5% in human toxicity potential.

ECOPROFILE	Scenario: IEC II Wind class - European Wind Farm - 95 m steel tower							
WASTE PRODUCTION	1 kWh electricity generated and distributed							
	UNIT	Upstream	Core process	Core Infrastructure	**TOTAL GENERATED**	Downstream Process	Downstream Infrastructure	**TOTAL DISTRIBUTED**
Hazardous waste non-radioactive								
Hazardous waste - to landfill	g	-	2,13E-04	2,86E-02	**2,88E-02**	6,33E-04	0,00E+00	**2,94E-02**
Hazardous waste - to incineration	g	-	0,00E+00	0,00E+00	**0,00E+00**	0,00E+00	0,00E+00	**0,00E+00**
Hazardous waste - to recycling	g	-	1,43E-02	8,71E-03	**2,31E-02**	5,07E-04	4,45E-04	**2,40E-02**
Hazardous waste radioactive								
Volume occupied, final repository for radioactive waste	m^3	1,74E-14	3,65E-14	5,40E-12	**5,46E-12**	1,20E-13	1,92E-13	**5,77E-12**
Volume occupied, final repository for low-active radioactive waste	m^3	3,99E-12	6,61E-13	1,38E-10	**1,43E-10**	3,14E-12	8,28E-12	**1,54E-10**
Other waste								
Non-hazardous waste - to landfill	g	-	2,49E-03	7,52E+00	**7,52E+00**	1,66E-01	4,14E-03	**7,69E+00**
Non-hazardous waste - to incineration	g	-	8,96E-05	9,91E-03	**9,99E-03**	2,20E-04	2,99E-04	**1,05E-02**
Non-hazardous waste - to recycling	g	-	1,30E-02	1,65E+00	**1,66E+00**	3,66E-02	7,32E-02	**1,77E+00**

3.4. Hot spot analysis and conclusions

In order to find the aspects which are mainly causing these environmental impacts, is needed to look into every phase of the whole life cycle from an integral perspective.

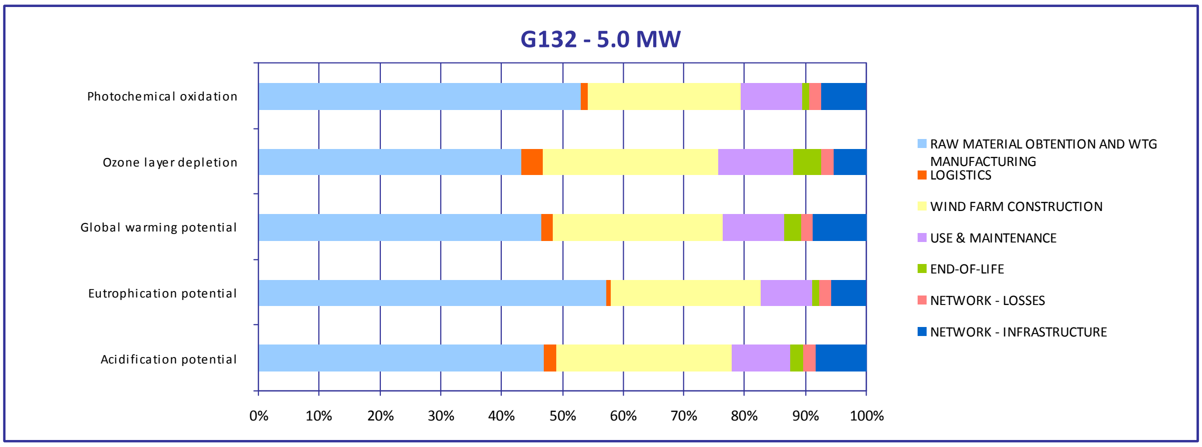

Figure 5.- Environmental hot spots

As shown in the figures above, there are two main phases within the life cycle responsible of approximately the 77% of all the environmental impacts in average. These are “Raw material obtention and WTG manufacturing” and “Wind farm construction”. For example, the “Raw material obtention and WTG manufacturing” goes from a 43% of the life cycle impacts in the category “Ozone layer depletion” to a maximum of 57% in the category “Eutrophication potential”. In the other hand, the phase “Wind farm construction” goes from a 25% in the category “Eutrophication potential” to a 29% in “Ozone layer depletion”.

For these reasons these stages are the most relevant phases within the life cycle of the energy generated by a GAMESA G132 - 5.0 MW from an environmental point of view and should be carefully designed in future projects. It should be pointed out that GAMESA is not a company dedicated to the energy distribution business, so that the environmental burdens of the electricity grid are outside of the direct range of GAMESA’s activities.

Nearly the 49% (in average for the 5 impact categories) of the environmental impacts of the energy generated and distributed by a GAMESA G132 - 5.0 MW WTG is caused in the “Raw material obtention and WTG manufacturing phase”. This is a logical consequence, since a wind turbine does not consume any fossil fuel during its operation as the conventional energy sources do, so the main environmental aspect of this technology is related to the manufacturing of its infrastructure. This is mostly caused by the raw materials needed to manufacture all the metal and plastic parts of the WTG and the subsequent machining phases. The most critical components in this phase are: the tower, the complete blades, the generator, the electrical cabinets / converter, the gearbox, the low speed shaft and the nacelle structures.

In relation to the “Wind farm construction”, it represents the 27% of the impacts (in average). The relevant environmental aspects for the construction are: civil works (materials, fuel and transport) and the materials needed for the foundations, the transformer substation, the internal wind farm wiring and the connection to the electrical grid.

The rest of the modules: “logistics” (2% in average), “use & maintenance” (10%), “end-of-life”(2%), “network - losses” (2%) and “network - infrastructure” (7%), have a minor contribution to the life cycle environmental impacts of the generated and distributed energy using GAMESA G132 - 5.0 MW Wind turbines. More detailed conclusions about the environmental impacts were made in the full LCA report. Please, refer to GAMESA for further information.

4. ADDITIONAL ENVIRONMENTAL IMPACTS

4.1. Impact on biodiversity

GAMESA conducts an Environmental Impact Assessment (EIA) for the wind farm projects for which it is required by the public administration. Nevertheless when such a study is not required by the public administration, GAMESA applies internal controls in order to ensure compliance with legal and internal environmental requirements.

Type of impact	Severe / Critical	Localization	Corrective measures
2 bird collisions (unidentified species)	No	High Voltage line Albarellos-Cando (LIC Serra do Cando) Spain	Environmental Monitoring: •forecast of accidents caused by collision/electric shock on a monthly basis, •Seasonal revision of flight interactions with the lines and/or towers, •Quarterly follow-up of prey birds •Revision of the general line status and revegetation of supports.
1 collision at Escribano Montesino (Emberiza cia) 2 possible collisions: a carrion crow (Corvus corone) and a common owl (Tyto alba)	No	High Voltage line Ameixeiras-Cando (LIC Serra do Candán) Spain	Environmental Monitoring: •forecast of accidents caused by collision/electric shock on a bi-monthly basis, •Seasonal revision of flight interactions with the lines and/or towers •Seasonal follow-up of prey birds •Revision of the general line status and revegetation of supports.
1 possible collision of common wood pigeon (Columba palumbus)	No	High Voltage Line Goia-Peñote (LIC Serra do Xistral) Spain	Environmental Monitoring: •forecast of accidents caused by collision/electric shock on a bi-monthly basis •Monthly revision of flight interactions with the lines and/or towers. •Monthly revision of the general line status Monthly revision of revegetation of supports.

Table 4.- Most significant impacts on biodiversity in 2013 (by type of impact)
(Source: GAMESA Sustainability report 2013 (Spain inventory) / http://www.gamesacorp.com)

4.1.1. Flora

The vegetation may be affected by the need of land preparation for wind farm installation and its degradation because of building works, accesses, roads, foundations and other elements of the site.

Therefore and to minimize these effects, when electing the place where the wind farm is going to be erected, GAMESA takes the measures listed below:

- Staking of all areas affected by the project prior to the start the construction, to avoid a physical repercussion higher than the strictly necessary.
- Proper gathering of soil extracted in excavations for its reuse in the restoration activities.
- Protection of the areas designated for using or handling of substances which may cause accidental spills, with pollution potential to soil and water, either surface water or groundwater.
- Reuse of the waste material which appeared during the execution of the excavations for laying out underground power lines and in the embodiment of concrete footings, for the conditioning and landscape restoration works.

- Restoration of vegetation affected by the work, in order to assure that the area does not remain occupied by road or infrastructures. Repopulate the area with bushes and scrubs of the same type of the ones in the surroundings.
- Not locating any element of the wind farm where it can affect any protected species.
- Replacement of woodland and scrub in the affected areas, on the cases that repercussion to adjacent forest land can't be avoided.
- Creating the new road accesses, using to the maximum the already existing paths. If not possible, rethink the layout trying not to affect these woodlands.
- Removal of all temporary facilities and all waste, debris and equipment used or generated during the execution of the works.

4.1.2. Fauna

Furthermore, the alteration of the natural environment has consequences on the fauna of the area, which also requires taking certain measures to reduce this way of impact:

- During the execution of the works for laying underground power lines, the intention is to close the trenches as soon as possible, avoiding falling animals.
- Looking for the location of wind turbines in non-forested areas where the presence of animals is reduced.
- Planting shrubs with fruit to offset the reduction in the usable area of the preserve and also enhancing the refuge for several species.
- Installing all the internal wiring of the wind farm in the underground, thereby avoiding electrocution of birds by contact with electrical power conductors.
- In case of any unavoidable outside line installation, proceed to place diverters on power lines to prevent electrocution of birds.
- Studying the potential impact of the wind farm on the wildlife in the area. If it is apparent from this study that the location of a wind turbine or other facility that integrates the wind farm represents a risk for autochthonous fauna, remove the installation as applicable.
- Monitor bird collisions with the goal of establishing corrective measures.

Considering all the measures, quantitative studies of the impacts are performed based on different indicators. To analyze the impact on vegetation the percentage of surface covered (PSC) indicator is used, which is calculated before and after the execution of works in order to determine its variation. This index suffers insignificant variations so that is concluded that the work only affects the vegetation units of lower ecological value, respecting the other units.

Regarding the impact on wildlife, especially on birds, it is determined that because of these preventive measures taken, the impact is small because the wind farms are placed in situations studied to affect as little as possible to their behaviour. Besides, the risk of collision of birds on the blades is reduced since they quickly become accustomed to the turbines.

4.1.3. Analysis of protected or restored habitat

GAMESA biodiversity strategy considers a combination of elements related to prevention, management and remediation of damage to natural habitats which might result from the operations. To ensure the existing natural integrity, aiming at the stability of the environmental resources, is critical the impact avoidance to local communities and the insurance of the minimum impact to the existing biodiversity.

Identification of species based on the IUCN red list and other species included in national lists which might be affected by Gamesa's activities is critical to take the necessary action to avoid endangering them. Gamesa's controls on biodiversity identify the following species present in wind turbine parts or high voltage lines, classified based on their risk of extinction:

Table 92.- Species in areas affected by operations [EN15]

Specie	Category IUCN	Affected wind turbine farm	Affected by high voltage line
Tetrax tetrax	NT	6	0
Pleurodeles waltl	NT	1	0
Neophron percnopterus	E	6	1
Milvus milvus	NT	6	1
Marmoronetta angustirostris	V	1	0
Sylvia undata	NT	6	4
Chalcides bedriagai	NT	2	1
Vipera latastei	V	2	3
Eliomys quercinus	NT	2	8
Numenius arquata	NT	1	1
Lutra lutra	NT	1	5
Alectoris graeca	NT	1	0
Stachys sprucei	V	1	0
Acinos alpinus meridionalis	NT	1	0
Colinus virginianus	NT	2	1
Staurotypus salvinii	NT	1	0
Rhinoclemmys rubida	NT	1	0
Convolvulus caput-medusae	NT	1	0
Oryctolagus cuniculus	NT	5	8
Timon lepidus	NT	3	5
Miniopterus schreibersii	NT	1	0
Rhinolophus mehelyi	V	1	0
Rhinolophus euryale	NT	1	0
Galemys pyrenaicus	VU	0	4
Arvicola sapidus	V	0	8
Chioglossa lusitanica	V	0	3
Rana iberica	NT	0	6
Lacerta schreiberi	NT	0	5
Achondrostoma arcasii	V	0	2
Cyprinus carpio	V	0	2
Anguilla anguilla	CE	0	5
Amphipterygium adstringens	E	0	1
Coracias garrulus	NT	0	2
Pelobates culprites	NT	2	0

Legend: LC=Least concerned; NT=Near threatened; VU=Vulnerable; EN=Endangered;CE=Critically endangered; EW=Extinct in the wild; EX=Extinct; (*): Under special protection (national)

Table 5.- Impact on species

4.1.4. Biodiversity studies

During the year 2013, 130 biodiversity studies have been conducted, including environmental impact, archaeology, birds, and noise assessments. These assessments are conducted during the promotion and construction stages of the wind turbine farm.

	2013	2012	2011	2010
Promotion stage				
Prior studies to the EIA (*)	-	1	10	17
Archeology	3	-	1	-
Environmental impact studies (EIA)	12	12	15	25
Birds and bats	39	15	33	7
Noise	15	1	15	-
Specific studies	38	9	31	23
Throughout the promotion stage	107	38	105	72
Construction stage				
Environmental Monitoring	10	5	1	7
Archeological monitoring	-	-	1	-
Others	1	-	3	-
Total construction stage	11	5	5	7
Construction stage				
Environmental Monitoring	5	7	19	7
Others	7	-	6	14
Total construction stage	12	7	25	21
Total biodiversity studies	**130**	**50**	**135**	**99**

(*) In 2013 studies prior to the EIA have been grouped with specific studies, since they were considered supplementary categories.

Table 6.- Biodiversity studies

4.2. Land use

4.2.1. Description of land use

The GAMESA G132 - 5.0 MW is a new machine and consequently there is no statistical data on G132 wind farms construction. For that reason, a similar and representative wind farm has been chosen for the land use analysis. This wind farm is “PE Cámara” located in the province of Málaga (Spain). It is composed of 4 WTGs of GAMESA 4.5 MW (18 MW in total). The wind farm is located in two different municipalities of the province of Málaga: Teba (SW) and Ardales (N), in the places known as “La Carguilla” and “Cabeza del Caballo”. In the municipality of Tebas 3 WTGs were installed and the remaining 1 in Ardales. The nearest population center is Ardales (9 km). Málaga is at a distance of 45 km from the wind farm. The access roads are paths out of the A-367 and A-357.

Predominantly agricultural activities (cereal crops and olive-trees) occupy most of the surrounding land. The total balance of the used land (access and internal roads, foundations (towers), platforms, trenches for internal wiring and transformer substation) was estimated in 52,500 m^2. The techniques used for this site construction works can be considered representative for a European wind farm case, according to experts in civil engineering from GAMESA.

An analysis of soil condition before and after wind farm installation is made. Below, the land use description of the selected wind farm is shown. This information has been extracted from the Environmental Impact Study (EIA) conducted before the construction of the wind farm.

4.2.2. Land use - Corine Land Cover classification

A land use classification based on the Corine Land Cover methodology (CLC) has been made. The occupied areas are shown in m². Below it is represented the land use of the mentioned wind farm "PE Cámara" prior to their installation:

BEFORE	PE Cámara
Artificial areas:	0 m²
Farming areas:	52,500 m²
Forest and semi-natural areas:	0 m²
Wetlands:	0 m²
Water:	0 m²
TOTAL:	**52,500 m²**

Table 7.- Previous land use

In the table below is represented the occupation of land, with the areas strictly occupied by the wind farm after installing it. The data extracted from the project is therefore "real ground uses", not administrative uses. They are taken from the work units thereof which are roads, foundations, platforms, trenches for internal wiring and the transformer substation.

AFTER	PE Cámara
Artificial areas:	49,500 m²
Farming areas:	3,000 m²
Forest and semi-natural areas:	0 m²
Wetlands:	0 m²
Water:	0 m²
TOTAL:	**52,500 m²**

Table 8.- Previous land use

4.2.3. Number of years of occupation

It is considered that the expected lifetime of the wind turbines is 20 years.

4.2.4. Description of the infrastructure in the occupied areas

The reference wind farm is composed of the following infrastructures:

- Access and internal roads (33,000 m²)
- Foundations (towers) (2,000 m²)
- Platforms (14,000 m²)
- Trenches for internal wiring (3,000 m²)
- Transformer substation (500 m²)
- *Transmission network[11] (19,000 m²)*

[11] Estimated value according to Ecoinvent and not considered in the calculation of land use for PE Cámara.

4.3. Environmental risks

GAMESA environmental risk analysis is performed at different stages of projects according to the criteria of the Standard ISO15008 - Analysis and environmental risk assessment. Although in general the probability and severity of undesirable events is generally very low and happens less frequent than once in three years, there were included those most representative events.

Radiology remains very low because of the lack of radioactive elements through the life cycle of the product, and the controls maintained during manufacturing processes.

This section includes all those undesirable events that can occur by chance but will produce relevant environmental impact.

Fire:
A fire emits a large amount of contaminating substances to the atmosphere and also produces waste when components are destroyed by the fire.

Oil spill:
Spills of oil, fuel and lubricants can cause local impacts on water and environmentally sensitive areas. At preventive maintenance operation, substances could be spilled accidentally. The impact of the spills would affect to environmentally sensitive areas.

Concrete spill:
The potential risks of concrete spill during transport of concrete may occur but probability is very low.

In the following table are quantified such impacts, where, by way of comparison, in the right column represent the emissions or other consequences under normal conditions.

POTENTIAL RISKS	Effect	Substances emitted to the air	Substances emitted to the land	Potential emissions at incidents in the process "Core" (g/kWh)	Potential emissions at incidents in the process "Core infrastructure" (g/kWh)	Emissions at normal conditions (g/kWh)
Spills of hazardous substances and chemicals	Affection to flora and wildlife	-	Oil, Diesel	< 10-5	< 10-4	0
Fires at Nacelle components	Emissions to the atmosphere	CO_2 and others	Waste	< 10-5	< 10-4	0
Concrete spills	Affection to flora	-	Concrete	< 10-5	< 10-4	0

Table 9.- Environmental risks

In conclusion, it is seen that the impact produced by the potential risks is considerably low.

4.4. Electromagnetic fields

The International Commission on Non-Ionising Radiation Protection (ICNIRP), an independent body consisting of international experts, has published recommendations regarding acute health problems. The recommendations are based on knowledge about acute health problems due to changing magnetic fields and propose a limit of 500 µT for working environment and for the general public a limit of 100 µT at 50 Hz.

Additionally and coming from the EMC Directive (2004/108/EC) (Electromagnetic Compatibility Directive), it is worth noting that EN 62311 and EN 62479 (included in the harmonised standards list for the LV Directive) cover human exposure restrictions for electromagnetic fields, and are relevant to WTG design; these two standards were taken into account in the specifications of the machine whose design is validated against these requirements, so we can say that although electromagnetic fields are generated, they will not cause harm to the health of people, being lower than those issued by the ICNIRP recommendations.

In the design of the machine, the requirements of IEC 62305-4 for the design of surge protection and in this case apply the design for lightning protection is a very important point of wind turbine design.

4.5. Noise

The noise produced by a wind turbine is twofold, one mechanics and other aerodynamics. The first comes from the machine components, and can easily be reduced by conventional techniques. Aerodynamic noise produced by the air flowing on the blades tends to increase with the speed rotation of the blades and with wind flow turbulent conditions noise may increase. Although inside nacelle the mechanical noise exists, it is low compared to aerodynamic noise, and at ground level in the G132, the only relevant noise is the aerodynamic one.

The G132 emitted noise values are within the normal values within the wind industry. Also noteworthy is that wind farms are located in uninhabited areas and distances greater than 300 m the noise level is greatly reduced and is considered negligible to be lower than the ambient noise threshold in nature, wind, etc.

Nevertheless, for locations with strict noise requirements, low noise operation modes are available for G132 model. In those versions, the total noise is limited to the required maximum value by reducing the power generated in the most critical wind speed bins.

4.5.1. Noise calculation

There are two international standards that establish noise measurement procedure and noise levels declaration:

- IEC 61400-11 (Ed. 3 2012): Wind turbine generator systems - Acoustic noise measurement techniques. Definition of how to perform noise measurements of a wind turbine.
- IEC 61400-14 (Ed. 2005): Wind turbines - Declaration of apparent sound power level. Definition of how to declare the noise generated by an AEG.
- G132 noise levels have been measured by authorized testing companies based on these standards, and reports are available for whoever is interested.

4.6. Visual impact

The landscape impact caused by the presence of wind turbines and power lines is a subjective aspect, which affects differently, depending on the location of the wind farm. The location of wind farms is also determined by analyzing the different points from which they are visible to, thereby causing minimal visual impact. Each wind farm prior to the decision to its location has had an environmental impact assessment that has been approved by the relevant environmental authority.

5. CERTIFICATION BODY AND MANDATORY STATEMENTS

5.1. Information from the certification body

The verification process of this environmental product declaration has been carried on by Rubén Carnerero Acosta, independent approved verifier by the International EPD® System, which verifies that the attached Environmental Product Declaration complies with the applicable reference documents and also certifies that the data presented by the manufacturer are complete and traceable in order to provide supporting evidence of the environmental impacts declared in this EPD document, according to the EPD - System General Programme Instructions.

The EPD has been made in accordance with the General Programme Instructions (version 2.01) for an Environmental Product Declaration, EPD, published by the International EPD Consortium and PCR version 3.0 2007:08 UN CPC 171 & 173: Electricity, Steam, and Hot/Cold Water Generation and Distribution. The verifier Rubén Carnerero Acosta has been accredited by the International EPD® System to certify Environmental Product Declarations, EPD. This certification is valid until the date 05-05-2018.

5.2. Mandatory statements

5.2.1. General

Note that EPDs within the same product category but from different programmes may not be comparable.

5.2.2. Life cycle stages omitted

According to the reference PCR, the phase of electricity use has been omitted, since the use of electricity fulfils various functions in different contexts.

5.2.3. Means of obtaining explanatory materials

The ISO 14025 standard requires that the explanatory material should be available if the EPD will be communicated to end users. This EPD is industrial consumer oriented (B2B) and communication is not intended for B2C (Business - to - Consumer).

5.2.4. Information on verification

EPD PROGRAMME AND PROGRAMME OPERATOR	
The International EPD® System Programme operator: EPD International AB Valhallavägen 81 SE-114 27 Stockholm - Sweden	
INDEPENDENT VERIFICATION OF THE DECLARATION AND DATA, ACCORDING TO ISO 14025:2006	
☐ EPD process certification ■ EPD verification	Rubén Carnerero Acosta Accredited or approved by: The International EPD® System
PRODUCT CATEGORY RULES (PCR)	
PCR 2007:08, Version 3.0 UN CPC 171 and 173: Electricity, Steam and Hot/Cold Water Generation and Distribution Date: 2015-02-05	
PRODUCT CATEGORY RULES (PCR) REVIEW WAS CONDUCTED BY	
The Technical Committee of the International EPD® System Chair: Massimo Marino	
VALID UNTIL	**REGISTER NUMBER**
5th May 2018	**S-P-00706**
GAMESA (GAMESA COPORACIÓN TECNOLÓGICA - GPT)	
Gamesa Parque Tecnológico de Bizkaia, Ed. 222 48170 Zamudio (Vizcaya) - Spain Phone number: + 34 944 317 600 e-mail: info@gamesacorp.com web: http://www.gamesacopr.com **Contact:** Corporate Communications C/ Ramírez de Arellano, 37 28043 Madrid - Spain Phone number: + 34 91 503 17 00 e-mail: media@gamesacorp.com	

6. LINKS AND REFERENCES

Additional information about GAMESA (Gamesa Corporación Tecnológica - GCT):
www.gamesacorp.com

Additional information about previous LCA and EPD reports made by GAMESA:
(G90 - 2.0 MW and G114 - 2.0 MW)
http://www.gamesacorp.com/en/products-and-services/wind-turbines/g9x-20-mw-en.html

Additional information about the International EPD® System:
www.environdec.com

General instructions of the programme (current version 2.01):
http://www.environdec.com/en/The-International-EPD-System/General-Programme-Instructions/

Key programme elements:
http://www.environdec.com/en/The-International-EPD-System/Key-Programme-Elements/

The International EPD® System is based on a hierarchical approach using the following international standards:

ISO 9001, Quality Management Systems
ISO 14001, Environmental Management Systems
ISO 14040, LCA - Principles and procedures
ISO 14044, LCA - Requirements and guidelines
ISO 14025, Type III Environmental Declarations

Database used for the LCA:
EcoInvent 3.1 (2014) Database, published by the Swiss Centre for Life Cycle Inventories
http://www.ecoinvent.org

Other references:
Asociación empresarial eólica – www.aeeolica.org
Comisión Nacional de la Energía – www.cne.es
Copper Development Association – www.copper.org
Council of European Energy Regulators - www.ceer.eu
Council of European Energy Regulators (CEER) – www.energy-regulators.eu
ESB group – www.esb.ie
Eurelectric – www.eurelectric.org
European Steel Association - www.eurofer.org
European Wind Energy Association – www.ewea.org
German Wind Energy Institute – www.dewi.de
Iberdrola – www.iberdrola.es
International Aluminum Institute - www.world-aluminium.org
International Electrotechnical Commission (IEC) - www.iec.ch (IEC 61400-1 WTG)
Red eléctrica española – www.ree.es
Worldsteel Association – www.worldsteel.com