GAMESA G90 2.0 MW

PCR	UN CPC 171 & 173: Electricity, Steam, and Hot/Cold Water Generation and Distribution Version 3.0
REGISTRATION NUMBER	S-P-00452
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FUNCTIONAL UNIT	1 Kwh of electricity generated through an on-shore wind farm of Gamesa G90 - 2.0 MW - 78m wind turbine generators, located on a European scenario and operating under medium wind conditions (IEC IIA) and thereafter distributed to a consumer connected to a 132 Kv grid

Content

1. INTRODUCTION

1.1. DECLARED PRODUCT

This document represents the certified Environmental Product Declaration (EPD), of the electricity generated through an on-shore wind farm of Gamesa G90 - 2.0 MW wind turbine generators with 78 meters high towers, located in a European scenario and operating under medium wind conditions (IEC IIA), and then distributed to a consumer connected to a 132 KV grid.

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 declared product is "1 Kwh of electricity generated through an on-shore wind farm of Gamesa G90 - 2.0 MW - 78m wind turbine generators, located on a European scenario and operating under medium wind conditions (IEC IIA) and thereafter distributed to a consumer connected to a 132 Kv grid"

Gamesa's G90 wind turbine generator has been successfully used worldwide for more than 9 years. 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 (Avoided 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.

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 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 (GPI). More information about the program can be found on www.environdec.com

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

- Product Category Rules, PCR 2007:08 UN CPC 171 & 173: Electricity, Steam, and Hot/Cold Water Generation and Distribution - Version 3.0.
- General Programme Instructions for Environmental Product Declarations, EPD, Version 2.5. (2015-05-11).
- ISO 14025 – Declaraciones ambientales Tipo III
- ISO 14040 and ISO 14044 on Life Cycle Assessment (LCA).

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

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

1.3. GAMESA, LCA AND EPD

Gamesa Corporación Tecnológica 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, we are 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 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 the different life cycle stages.

From this starting point, a further step is the certification by an Environmental Product Declaration of the energy generated and distributed using Gamesa G90 wind turbines, ensuring the reliability of the data used for the LCA as well as the transparency about the environmental performance of our products.

1.4. DIFFERENCES FROM PREVIOUS VERSIONS

The following EPD, represents the first update of the certified environmental declaration made by Gamesa on 2013, which was referred to the environmental performance of their on-shore G90 2.0 MW wind farms.

This update is a requirement needed to extend the validity of the reported data for three years and to adapt the information to the latest version of the product category rules (version 3.0)

In the following paragraph, the main differences between the previous and the updated EPD version are collected.

- The Ecoinvent life cycle inventories database, which provides the basis for the LCA sustaining the reported data, has been updated to its 2.2 version.
- The electricity mix indicator used for the manufacturing of the wind turbine generators has been updated to its 2014 version, in order to obtain a better representation of this life cycle stage.

- The biogenic CO_2 emissions to air have been included in the environmental impact category "Global warming potential (100 years)", as required in the latest PCR version. In addition, this value is reported separately.
- The structure of the eco-profile tables has been reorganized, adapting them to the latest PCR requirements.
- The information about the company has been updated (section 2.1).
- The characterization factors of all the environmental impact categories assessed have been updated to the CML 2001 version of April 2015, as recommended by the International EPD System.
- The functional unit has been updated. This EPD is now making reference to the energy generated and distributed to a customer connected to a 132 KV electrical grid. This change only affects the downstream section of the results, related to the energy transport and distribution stage.
- Due to an improved performance of the product, the technical availability of the wind turbine generator has been updated to 98%, which is its new value.

	G80-2.0 MW	G87-2.0 MW	G90-2.0 MW	G97-2.0 MW	G114-2.0 MW	G114-2.5 MW
ROTOR						
Diameter	80 m	87 m	90 m	97 m	114 m	114 m
Swept area	5,027 m²	5,945 m²	6,362 m²	7,390 m²	10,207 m²	10,207 m²
Rotational speed	9.0 - 19.0 rpm	9.0 - 19.0 rpm	9.0 - 19.0 rpm	9.6 - 17.8 rpm	7.8 - 14.8 rpm	7.7 - 14.6 rpm
BLADES						
Number of blades	3	3	3	3	3	3
Length	39 m	42.5 m	44 m	47.5 m	56 m	56 m
Airfoils	NACA 63.XXX + FFA-W3	DU + FFA-W3	DU + FFA-W3	Gamesa	Gamesa	Gamesa
Material	Pre-impregnated epoxy glass fiber	Pre-impregnated epoxy glass fiber	Pre-impregnated epoxy glass fiber	Pre-impregnated epoxy glass fiber + carbon fiber	Fiberglass reinforced with polyester resin	Fiberglass reinforced with polyester resin
TOWER						
Type	Modular	Modular	Modular	Modular	Modular	Modular
Height	60, 67, 78 and 100 m	67, 78, 90 and 100 m	55, 67, 78 , 90 and 100 m	78, 90, 100 and 120 m	80, 93, 125 m and site specific	80, 93, 125 m and site specific
GEAR BOX						
Type	1 planetary stage 2 parallel stages	1 planetary stage 2 parallel stages	1 planetary stage 2 parallel stages	1 planetary stage 2 parallel stages	1 planetary stage 2 parallel stages	2 planetary stages 1 parallel stage
Ratio	1:100.5 (50 Hz) 1:120.5 (60 Hz)	1:100.5 (50 Hz) 1:120.5 (60 Hz)	1:100.5 (50 Hz) 1:120.5 (60 Hz)	1:106.8 (50 Hz) 1:127.1 (60 Hz)	1:128.5 (50 Hz) 1:102.5 (60 Hz)	1:129.7 (50 Hz) 1:103.8 (60 Hz)
GENERATOR						
Type	Doubly-fed machine	Doubly-fed machine	Doubly-fed machine	Doubly-fed machine	Doubly-fed machine	Doubly-fed machine
Rated power	2.0 MW	2.0 MW	2.0 MW	2.0 MW	2.0 MW	2.5 MW
Voltage	690 V AC	690 V AC	690 V AC	690 V AC	690 V AC	690 V AC
Frequency	50 Hz / 60 Hz	50 Hz / 60 Hz	50 Hz / 60 Hz	50 Hz / 60 Hz	50 Hz / 60 Hz	50 Hz / 60 Hz
Protection class	IP 54	IP 54	IP 54	IP 54	IP 54	IP 54
Power factor	0.95 CAP - 0.95 IND throughout the power range*	0.95 CAP - 0.95 IND throughout the power range*	0.95 CAP - 0.95 IND throughout the power range*	0.95 CAP - 0.95 IND throughout the power range*	0.95 CAP - 0.95 IND throughout the power range*	0.95 CAP - 0.95 IND throughout the power range*

* Power factor at generator output terminals, on low voltage side before transformer input terminals.

2. THE COMPANY AND THE PRODUCT

2.1. GAMESA CORPORACIÓN TECNOLÓGICA

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, US, 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.

Gamesa

The Company is certified to the following management systems:

- ISO 14001:2004 – Environmental management systems
- ISO 14006:2011 – Environmental management systems. Guidelines for incorporating ecodesign. 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
- ISO 9001:2008 - Quality management systems
- OHSAS 18001:2007 – Occupational health and safety management systems

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

2.2. PRODUCT SYSTEM DESCRIPTION

The baseline system under study is an on-shore wind farm composed of Gamesa G90 2.0MW wind turbine generators, resting upon 78m high steel towers, operating under medium wind conditions (IEC II) and located on a European scenario.

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 are inside the system boundaries.

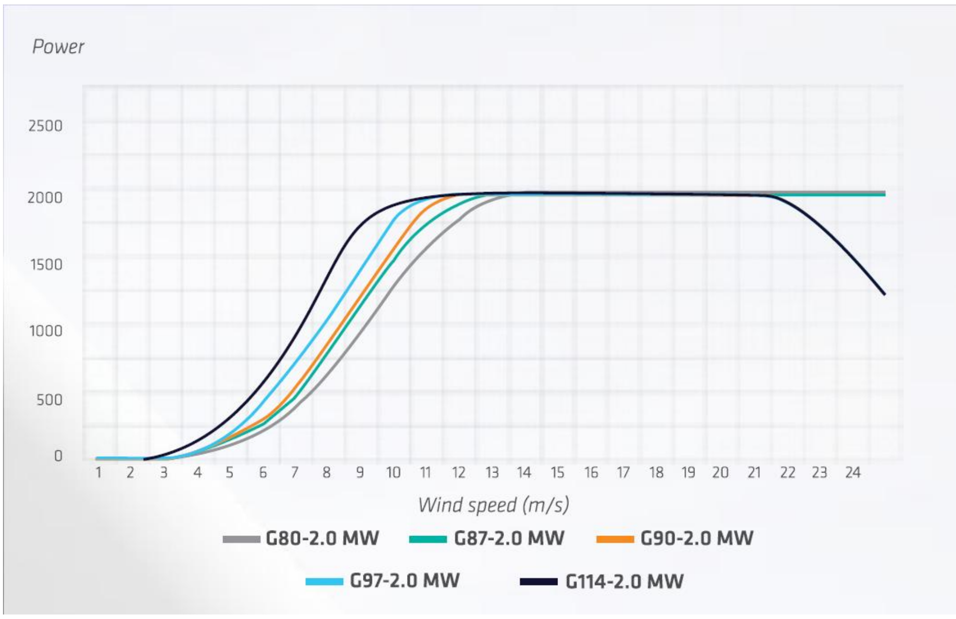
The declared unit is 1 Kwh generated and distributed to a consumer connected to a 132 KV network. Accordingly, the infrastructure needed for the electrical transmission and distribution of the generated electricity until the customer is also included in the present declaration, as well as the inevitable losses that will occur in the electrical transportation stage.

2.2.1. THE GAMESA G90-2MW WIND TURBINE GENERATOR

The multi-megawatt wind turbine Gamesa G90-2.0MW bases its technology on the variable pitch control incorporating the latest technologies to extract the maximum power from the wind with the greatest efficiency. The G90 is a two-megawatt power turbine, has a three-blade rotor of 90 m diameter and a swept area of 6,362 m2. The WTG has both aerodynamic and hydraulic braking systems, lightning protection in accordance with IEC 61024-1, pitch angle control for each of its blades and it is supported by a tapered tower of 78 meters height consisting in four steel sections.

AEP = Annual energy production = 8,119 Mwh/year
Availability of the machine = 0.98%
Lifetime = 20 years

The G90-2.0MW wind turbine has been designed to optimize the cost of energy and performance in low and medium wind sites. 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.



Some general advantages of the G90-2.0MW WTG:

- Maximum production at any location.
- Pitch system and variable speed to maximize energy production
- New optimized blade profiles for maximum output and low noise
- Composites reinforced with fiberglass and carbon to achieve lighter blades while maintaining the rigidity and strength
- Technological solutions to ensure compliance with the main requirements of international transmission grid connection.
- Active yaw system to ensure optimal adaptation to complex terrain
- Aerodynamic design and GAMESA NRS ® control to minimize noise emissions
- GAMESA WindNet ®: control and monitoring system with remote web access
- GAMESA SMP own predictive maintenance system

The Gamesa G90-2.0MW is part of the 2.0-2.5MW platform. The key characteristics of this platform are its robustness, stellar reliability and suitability for all kinds of sites and wind conditions, from the most challenging locations to low and medium wind speed sites.

Thanks to this performance, the platform's installed capacity stands at over 15,000 MW worldwide, while average fleet availability is running at over 98%. These turbines enable competitive CoE ratios per MW installed, thanks to the versatile combination of rotors, nominal power and tower height, to achieve peak performance in all kinds of locations and wind conditions.

2.2.2. THE WIND FARM

Since GCT started the LCA study, it was found interesting the concept that its results could be extrapolated as far as possible to an average European wind farm and not only to a 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 create a generic model representing a European average wind site. This LCA model has been made from actual data known from previously installed Gamesa 2.0 MW wind farms.

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 sites. These two parameters are individually analyzed in the next paragraphs.

Once existing environmental aspects were individually analyzed for the different types of wind farms, an average allocation was made for the raw material and the machinery use needed for every installed WTG. Thus, the impact arising from the construction of the wind farm is allocated to each wind turbine installed and not limited to a particular emplacement size.

As the study refers to an average G90 wind farm, for the infrastructures shared by many WTGs (i.e. transformer substation, internal wiring, connection infrastructure to the electrical network, road conditioning to allow the access to machinery...), the average wind park size of 28,5 MW installed has been used as baseline.

2.2.2.1. LOCATION

The location of the wind plant is directly related to the environmental impact caused in the distribution phase. The farther the wind farm is, the more logistics needed. To determine the geographical locations which need to be assessed in order to achieve a LCA model representative of the actual situation, first of all, the European locations where Gamesa has a higher G90-2.0MW installed capacity were identified. These are the results:

Country	Number of Wind farms	WTG Model	Nominal power (KW)	Number of installed WTG	Installed capacity (MW)	Relevance (%)
SPAIN	95	G90	2000	1097	2194	57,49%
POLAND	17	G90	2000	246	492	12,89%
FRANCE	35	G90	2000	172	344	9,01%
ITALY	9	G90	2000	120	240	6,29%
HUNGARY	10	G90	2000	91	182	4,77%
ROMANIA	3	G90	2000	70	140	3,67%
BULGARIA	5	G90	2000	45	90	2,36%
PORTUGAL	3	G90	2000	32	64	1,68%
TURKEY	1	G90	2000	15	30	0,79%
SWEDEN	3	G90	2000	10	20	0,52%
CYPRUS	1	G90	2000	10	20	0,52%

From this table, we can conclude that the 85.7% of the installed power using G90-2.0MW WTGs, is focused in 4 countries which are Spain, Poland, France and Italy. The other European countries where Gamesa is present using this model of turbine, represent less than a 5% of the total installed capacity each. Because of this, when calculating the distances covered by the WTG components from the manufacturing plants until the wind farm, 4 different transport scenarios were created (1 for each analyzed country) taking into account the real distances from the manufacturing plants until the specific regions where higher capacity is installed.

The studied regions are the ones contained in the table:

SPAIN	
REGION	INSTALLED CAPACITY
Andalusia	36.71%
Castile and Leon	36.71%
Castile – La mancha	17.17%
Catalonia	6.31%
POLAND	
REGION	INSTALLED CAPACITY
Warmia-Masuria	26.83%
Greater Poland	24.39%
Pomerania	14.63%
Masovia	10.98%
FRANCE	
REGION	INSTALLED CAPACITY
Meuse	38.37%
Aisne	19.19%
Morbihan	13.95%
Ardennes	9.30%
ITALY	
REGION	INSTALLED CAPACITY
Sicily	66.67%
Calabria	25.00%
Tuscany	8.33%

Finally, a relative weighting was applied to each logistics scenario, depending on its installed capacity. In view of other alternative scenarios investigated by Gamesa Corporación Tecnológica, it can be assumed that the location of the wind farm won't represent a relevant environmental aspect, since its contribution to the global impacts of the generated electricity is lower than the 2.4% for every assessed impact category.

2.2.2.2. SIZE OF THE WIND FARM

The other relevant parameter regarding the wind farm is the overall size. The environmental impacts of the generated electricity depend directly on this parameter, because there are some infrastructures that are shared by all the WTGs. Some examples are the electrical substation, the underground wind farm wiring or the overhead electrical lines required to reach the main network connection point. Likewise, some activities like the conditioning of road accesses will be performed in the same way whether multiple WTGs are commissioned or not.

Accordingly, is easy to deduce that in general terms, building bigger wind farms is more sustainable than building smaller ones, because the impact caused by the construction of the common infrastructures will be divided among all the installed turbines.

In order to reflect this relationship between the wind farm size and the environmental impacts caused, data from different emplacements built by Gamesa have been collected, covering different sizes. Finally, for the data needed to assess the environmental impact related to the building works of the emplacement, data belonging to different Spanish 2.0 MW construction sites has been used.

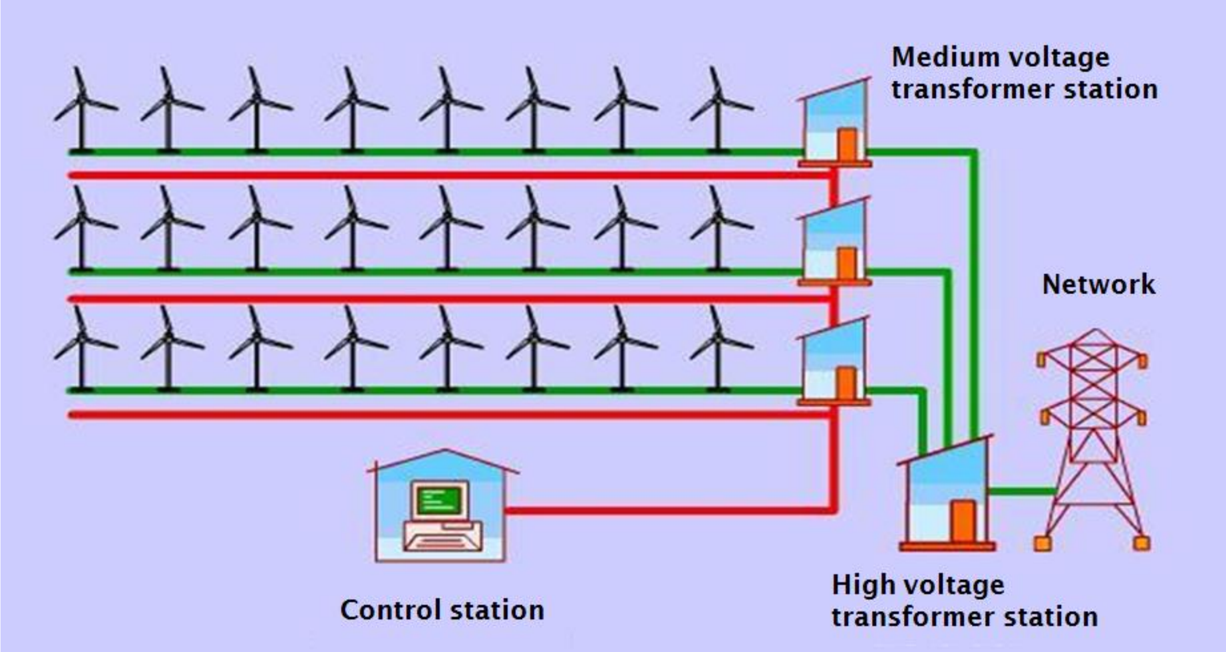
WIND FARM	LOCATION	NUMBER OF WTG	INSTALLED CAPACITY	YEAR OF CONSTRUCTION
Alto de la degollada	Castrojeriz (Spain)	25	50 MW	2010
Los Lirios	San Silvestre de Guzmán (Spain)	24	48 MW	2010
Barchín	Barchín del hoyo (Spain)	14	28 MW	2011
Les Forques II	Passanant (Spain)	6	12 MW	2011

Although all analyzed sites are 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.

When allocating the environmental burdens to the previously mentioned common elements, whose quantity doesn't depend on the installed capacity, the average size of a European wind farm composed of 2.0MW WTGs and commissioned by Gamesa has been used, that is 28.5 MW of installed power.

After conducting the analysis of the different wind farm typologies, the results have been extrapolated in order to obtain theoretical values of the environmental impacts derived from the construction of the site and its associated infrastructures, individually allocated to 2.0 MW of installed power.

Consequently, the LCA model created which supports this EPD, represents an average on-shore European G90 2.0 MW wind farm.



2.2.3. ELECTRICITY TRANSMISSION AND DISTRIBUTION INFRASTRUCTURE

Once the wind is converted into electricity wind turbine generator, the energy is delivered to each consumer through the electrical transmission and distribution network. This electrical transport stage also entails some environmental impacts that cannot be left out.

On one hand, we must consider the environmental impacts associated with the construction and dismantling of the infrastructure needed to transport all the electricity generated by the WTGs. The materials used to build these overhead lines, depend on the voltage level of the electricity being transported in every step, from the power generation until later consumption.

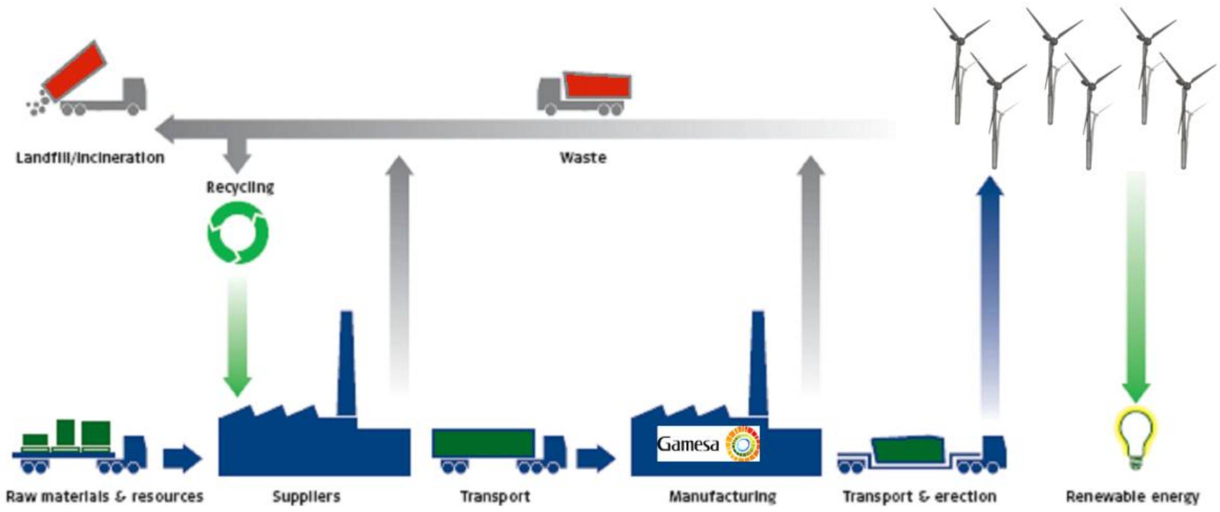
Furthermore, the electrical losses which occur as a result of the inevitable heating of electric wires during transport and in the successive voltage transformations that occur until the consumption point cannot be avoided. All these impacts have also been taken into account in the system under study.

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 the activities managed by Gamesa. The data required for modeling 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 wind energy life cycle, includes several different stages following a cradle-to-grave approach. This encompasses all the phases from the extraction of the first raw material needed to build the WTG, the wind farm or the electrical networks, until the decommissioning and end of life treatment of every of the components and parts involved, as well as all the manufacturing processes carried out by Gamesa and its multiple providers. Moreover, all the logistics and the 20 years of operation and maintenance are included as well.

The following figure encompasses the full cradle-to-grave life cycle of the energy generated through a wind farm. In this complex framework, the system boundaries need to be clearly established in order to avoid misunderstandings.



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 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, maintenance travels, 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 G90 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.

2.2.4.2. UPSTREAM MODULE

The upstream module considered in the 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), until the moment when it reaches the final consumer. Thus, for this stage it is necessary to consider not only the construction and dismantling of the electrical network required for the energy transportation, but also the inherent losses during the electrical transport and voltage transformation.

3. ENVIRONMENTAL PERFORMANCE BASED ON LCA

3.1. LIFE CYCLE ASSESSMENT METHODOLOGY

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

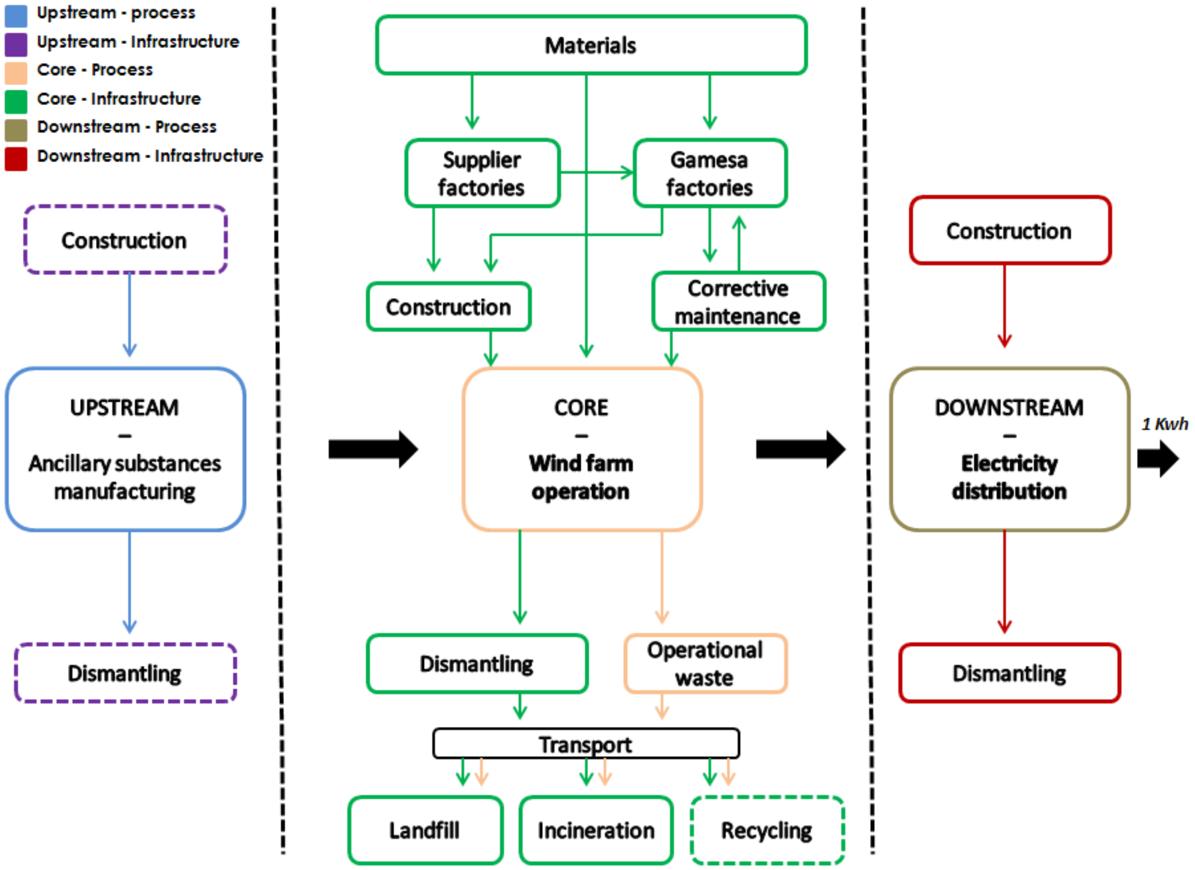
The LCA only quantifies information on environmental impacts, leaving apart social and economic indicators. In the same way, some environmental impacts associated with the product life cycle as land use, impacts on biodiversity, electromagnetic fields, noise, visual impact or accidental risks cannot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

3.2. SYSTEM BOUNDARIES AND DATA SOURCES

This Environmental Product Declaration reflects the life cycle impact of the electricity generated through an on-shore wind farm of Gamesa G90 - 2.0 MW - 78m wind turbine generators, located on a European scenario and thereafter distributed to a European power transmission grid.

The cradle-to-grave approach comprises the raw material extraction stage, the logistics from the providers until the wind site, the manufacturing processes, the construction and decommissioning of the whole wind farm, the 20 year operation and the end of life management of all the relevant infrastructures. In addition, the electricity distribution stage which goes from the electrical substation of the wind farm until a customer connected to a 132 KV grid is also inside the system boundaries.

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.



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 associated PCR. The arrows represent the different transport stages for the 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 directly from Gamesa or 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 GCT has direct access to, have been included in the analysis seeking the best data completeness. However, given the complexity of the system and the multitude of information needed and in order to ease the assessment, the following cut-off criteria have been followed when making the life cycle inventory:

- The sum of all material flows that have not been included in the analysis should be less than 1% of the total weight of all material flows.
- The sum of all energy flows that have not been included in the analysis should be less than 1% of the total energy flows.
- The replacement of components that have a lower failure rate than 0.009 failures per WTG during the entire service life, have not been included in the analysis.

By the time the study ended, the 99,94% of the total material flows of the system had been successfully included (99,05% of the total materials of the wind turbine, as well as the 100% of the materials used to build the wind farm). In addition, all the energy flows incurred in Gamesa manufacturing plants have also been included in the analysis.

From these primary data, when creating the life cycle model of the analyzed system the Ecoinvent 2.2 life cycle inventories database has been used. Ecoinvent is the most famous LCA database worldwide used by around 4,500 users in more than 40 countries. 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 is the world's leading supplier of consistent and transparent life cycle inventory (LCI) data of known quality.

All the data used to create the life cycle model of the electricity generated by an on-shore G90-2.0MW-78m wind farm, reflect the technology currently used by Gamesa Corporación Tecnológica and are considered representative for the period of validity of this EPD.

3.2.1. CORE - INFRASTRUCTURE

Data on the materials needed for construction and subsequent decommissioning of each G90 2.0MW WTG, represent the technology currently used by Gamesa Corporación Tecnológica for the manufacturing of this turbine model.

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 and the internal wiring of the wind farm, were obtained from data and inventories of real G90-2.0MW on-shore wind farms construction projects conducted by Gamesa. The analyzed wind farms were identified on paragraph 2.2.2. The EPD verifier had access to more comprehensive information on the data used for this modelization. This data are representative of the technology currently used by Gamesa Corporación Tecnológica, as long as new building methods are not developed.

GCT is responsible for the manufacturing of most of the major components of the wind turbine. Data on Gamesa production processes have been obtained from measurements and records obtained in the own Gamesa manufacturing plants during the period 2008-2010. These data are based on the technology currently used by GCT, and are considered representative as long as the same manufacturing technologies are used.

In the case of an on-shore G90 2.0MW WTG delivered to any European location, the factories involved in the manufacturing of the machine are the ones collected in the following table. All these manufacturing plants have been individually assessed for the purpose of the study:

MANUFACTURING PLANTS			
#	NAME	LOCATION	COMPONENT
1	Gamesa Ágreda	Ágreda (Soria)	Nacelle assembly
2	Gamesa Cantarey	Reinosa (Cantabria)	Generator manufacturing
3	Gamesa Componentes eólicos Albacete	Albacete (Albacete)	Blades manufacturing
4	Gamesa Componentes eólicos Cuenca	Cuenca (Cuenca)	Blade roots manufacturing
5	Gamesa Echesa	Asteasu (Guipuzcoa)	Gearbox parts machining
6	Gamesa FNN Burgos	Burgos (Burgos)	Casting
7	Gamesa MADE Medina del Campo	Medina del Campo (Valladolid)	Rotor assembly
8	Gamesa TRELSA Lerma	Lerma (Burgos)	Gearbox assembly
9	Gamesa Valencia Power Converters	Benissanó (Valencia)	Converter and electrical cabinets manufacturing
10	Apoyos y Estructuras Metálicas Olazagutía	Olazagutía (Navarra)	Tower manufacturing

The "Apoyos y Estructuras Metálicas Olazagutía" manufacturing plant does not belong to GCT as the other plants contained in the previous table do. Given the fact that Gamesa is in charge of designing the tower component and that this component is especially relevant in the final environmental results, has been found interesting to deeply analyze this factory with the same level of detail as the factories owned by Gamesa. This approach has only been possible with the kindly cooperation of the enterprise "WINDAR Renewable Energy".

In these centers, the main environmental aspects for every of the single manufacturing processes have been inventoried during a 1 year period. Starting from these records and from the annual component production in each manufacturing plant, the pertinent relation has been established between them and every Kwh of electricity generated and thereafter distributed to the customer.

When further allocation has been required (e.g. in plants where components for different WTG models are manufactured), physical allocation criteria were used to resolve multifunctionality issues, as recommended by the PCR. In the plants where a correct data split has been possible, the energy consumption not related to production purposes (general services, offices, lightning and heating) has been omitted. As all the manufacturing centers are located in Spain, the Spanish 2014 electricity mix has been used to model the electricity consumption of these plants. Red Eléctrica Española is the data source used to create the electricity mix environmental indicator. Water consumption which is not directly related to production purposes has also been omitted from the study.

In addition to this processes, in the table below the main suppliers that were considered for the LCA are also listed:

MAIN SUPPLIERS		
#	CONCEPT	SUPPLIER
1	Electrical cabinet covers	HERCOR
2	Rear frame	ARAÍN
3	Front frame	SAKANA - LAKBER - GOILAK
4	Low speed coupling	STÜWE
5	High speed coupling	ZERO MAX
6	Oil	SHELL
7	Transformer	ABB
8	Yaw ring	REDUCEL
9	Ultrasonic anemometer	ADOLF THIES
10	Anemometer	NRG
11	Wind vane	NRG
12	Paint	HEMPEL - MANKIEWICZ
13	Pitch system & Hydraulic group	HINE
14	Nose and cover	IMPRE
15	Blade bearings	ROLLIX
16	Pre-preg	GURIT

The manufacturing processes carried out by Gamesa suppliers, have been analyzed through the combination of data on manufacturing processes from Ecoinvent 2.2 database and data provided by the suppliers themselves.

All the G90 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 reinvestment of components, the impact of performing corrective maintenance actions on G90 2.0 MW machines has been modeled in the LCA which supports this EPD.

Data on failure rate statistics have been taken directly from internal studies made by GCT. In combination with these data, the repair activities carried out by Gamesa in its manufacturing plants has also been assessed, with the objective of knowing the recovery rate capacity arisen from GCT efforts to fix critical modules as generators, gearboxes, blades or transformers for example. This effect is considered in the core infrastructure module. Data on failure rates for the main G90 WTG components have been obtained from an internal study conducted by GCT during the year 2008. Data on recovery rate capacities were collected from different Gamesa repair facilities between the years 2008 and 2011.

Finally, the materials that appear after the decommissioning of the wind farm and their end-of-life management have been estimated according to the following sources:

- Gamesa's wind turbine generators recycling manual. Source: AMBIO
- Decommissioning project of the Igea-Cornago sur wind farm. Source: GER
- Analysis of end of life options for wind turbine blades. Source: GAIKER

For the LCA the following hypotheses have been assumed.

- 98% of the metals (ferrous or not) are sent to recycling processes.
- 90% of the polymers are sent to recycling processes
- 50% of the electronic components are sent to recycling processes
- 99% of the cables are sent to recycling processes
- 100% of the oils are sent to energy recovery processes
- 0% of the glass fibers and carbon fibers are recycled (100% landfill)
- 0% of the paints and adhesives are recycled

3.2.2. CORE - PROCESS

All the environmental impacts associated with the operation of the wind farm, given its 20 years of service 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 in this stage when we look at the results.

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

- Preventive maintenance required during the lifespan of the wind farm, including the maintenance routes of the technical staff to the wind farm.
- Data on the need for consumables allowing the correct operation of the WTG. This information has been obtained from the maintenance manual and the lubrication instructions of the G90 - 2.0MW WTG. This document is currently used as a guide for the maintenance of the machine and is considered representative for the period of validity of the EPD.
- The proper waste management of the consumables needed during operation and maintenance of the wind farm, including transportation stage to the authorized entity for later management.

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 Corporación Tecnológica. This includes aspects such as annual energy generation, machine availability, energy losses in the wind farm, maintenance protocols, etc. These data reflect the technologies currently used by Gamesa Corporación Tecnológica 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 covers 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 included:

- Production of the quantities of hydraulic oil, lubricating oil and fat by Gamesa's suppliers.
- All the logistics 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 preventive maintenance were obtained from the lubrication charts and from the maintenance manual of the G90. These documents 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.

Suppliers' manufacturing processes data have been obtained from Ecoinvent life cycle inventories database. The emissions derived from the transport stages of these ancillary substances have been obtained from Ecoinvent as well. The infrastructure and the equipment of the suppliers of the auxiliary substances needed for the correct operation of the wind farm have been excluded from the analysis, as allowed by the PCR.

3.2.4. DOWNSTREAM

The quantity of energy yearly sent to the distribution network by each Gamesa G90-2.0MW WTG, has been obtained from the power curves and the expected operation conditions of the machine in a IEC-II wind class type site.

The downstream module represents mainly two different environmental impacts. The first one is related to the electrical losses inherent to the voltage transformations and to the Joule effect when transporting the generated electricity, which are considered in the sub-module "downstream process". Note that these losses depend on the connection voltage of the final consumer. The downstream process module in this case, covers the electricity losses from a network point known as the Point of Common Coupling (PCC) until an average European customer connected to a 132KV network. Due to the difficulties encountered by Gamesa to quantify the distributed electricity share for every type of European customer, an average value of 2.2% has been considered to simulate these losses. This means that the 2.2% of every Kwh injected in the PCC, is lost due to electricity transmission losses before it reaches the customer connected to 132 KV.

The second impact is related to the construction and decommissioning of the electrical grid, which is considered within the sub-module "downstream infrastructure". With regard to the electrical transmission and distribution system infrastructure, the existing infrastructures on the four European countries that were found more representative of the Gamesa situation were analyzed. These countries are Spain, Poland, France and Italy. After combining the available infrastructure in each country with the specific energy demand, the number of km of electrical grid needed to include in the LCA were calculated. The data used for the modelization of the electrical grids have been obtained from the Ecoinvent 2.2 database.

3.3. ECO-PROFILE

In the following tables, it is shown the environmental behavior of the G90-2.0 MW 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 declared product is "1 Kwh of electricity generated through an on-shore wind farm of Gamesa G90 - 2.0 MW - 78m wind turbine generators, located on a European scenario and operating under medium wind conditions (IEC IIA) and thereafter distributed to a consumer connected to a 132 KV grid"

ECO-PROFILE	UNIT	IEC II Wind Class - European Wind Farm - 78 m Tower						
USE OF RESOURCES		1 KWh electricity generated and distributed to a 132 KV customer						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Non-renewable material resources								
Gravel	g	4,601E-03	1,169E-02	3,141E+01	3,142E+01	6,913E-01	9,774E-02	3,221E+01
Iron	g	4,476E-04	8,783E-04	1,759E+00	1,760E+00	3,872E-02	5,199E-02	1,851E+00
Calcite	g	5,589E-04	8,437E-04	1,324E+00	1,325E+00	2,916E-02	3,118E-02	1,386E+00
Clay	g	5,557E-04	2,348E-04	5,185E-01	5,193E-01	1,142E-02	2,188E-02	5,526E-01
Nickel	g	2,587E-05	1,584E-05	1,713E-01	1,713E-01	3,769E-03	7,906E-04	1,759E-01
Sodium chloride	g	4,972E-05	4,987E-04	1,081E-01	1,087E-01	2,391E-03	3,201E-03	1,143E-01
Chromium	g	9,884E-06	5,856E-06	7,022E-02	7,023E-02	1,545E-03	2,067E-04	7,199E-02
Aluminium	g	1,497E-05	3,561E-05	4,069E-02	4,074E-02	8,963E-04	1,469E-02	5,632E-02
Colemanite	g	7,801E-08	9,803E-09	3,621E-02	3,621E-02	7,967E-04	3,506E-05	3,704E-02
Other non-renewable resources[1]	g	2,303E-04	8,053E-05	8,679E-02	8,710E-02	1,916E-03	9,778E-03	9,879E-02
Non-renewable energy resources								
Nuclear	MJ	6,602E-05	6,898E-05	1,523E-02	1,537E-02	3,381E-04	5,985E-04	1,630E-02
Crude oil	MJ	1,682E-03	4,014E-04	3,484E-02	3,692E-02	8,123E-04	1,134E-03	3,887E-02
Lignite	MJ	2,821E-05	1,151E-05	4,874E-03	4,914E-03	1,081E-04	2,195E-04	5,242E-03
Hard coal	MJ	3,750E-05	2,716E-05	3,738E-02	3,745E-02	8,239E-04	1,336E-03	3,961E-02
Natural gas	MJ	1,528E-04	5,316E-05	2,569E-02	2,590E-02	5,697E-04	5,568E-04	2,702E-02
Renewable material resources								
Wood	m3	2,070E-04	8,593E-05	4,548E-02	4,578E-02	1,007E-03	1,225E-02	5,903E-02
Water use								
Total amount of water use	m3	6,574E-07	4,377E-07	1,852E-04	1,863E-04	4,100E-06	6,774E-06	1,972E-04
Direct amount of water in the core process	m3	-	1,154E-08	-	1,154E-08	2,539E-10	-	1,180E-08
Renewable energy resources								
Energy from hydro power	MJ	8,580E-06	1,256E-05	5,845E-03	5,866E-03	1,291E-04	4,941E-04	6,489E-03
Energy from biomass	MJ	3,459E-06	1,561E-06	8,865E-04	8,915E-04	1,961E-05	1,919E-04	1,103E-03
Wind electricity	MJ	1,166E-06	4,652E-07	6,506E-04	6,522E-04	1,435E-05	4,128E-06	6,707E-04
Solar electricity	MJ	1,708E-08	1,318E-08	1,160E-04	1,160E-04	2,552E-06	6,096E-08	1,186E-04
Electricity use in the wind farm[2]	Kwh	-	5,800E-02	-	5,800E-02	1,276E-03	-	5,928E-02
Secondary resources								
Aluminium	g	-	-	9,348E-03	9,348E-03	2,057E-04	-	9,554E-03
Copper	g	-	-	6,408E-03	6,408E-03	1,410E-04	-	6,549E-03
Steel	g	-	-	8,507E-01	8,507E-01	1,871E-02	-	8,694E-01
Recovered energy flows	MJ	-	-	-	-	-	-	-

The list of the reported non-renewable material resources, are the ones whose contribution to the weight of the material input flows is higher than 0.1%. The rest of the non-renewable material resources are reported as aggregated data, and represent the 0.25% of the total raw material input flows.

[1] Sum of 83 substances.

[2] The electricity used in the wind farm is generated by the wind turbines itself. The environmental impact in conjunction with this electricity consumption has been included in the results.

ECO-PROFILE	UNIDAD	IEC II Wind Class - European Wind Farm - 78 m Tower						
POLLUTANT EMISSIONS		1 KWh electricity generated and distributed to a 132 KV customer						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Potential environmental impacts								
Acidifying gases	g SO_2 eq	2,254E-04	1,303E-04	3,408E-02	3,444E-02	7,576E-04	2,549E-03	3,774E-02
Eutrophying substances	g PO_4 eq	5,295E-05	5,265E-05	1,719E-02	1,729E-02	3,805E-04	2,379E-03	2,005E-02
Global warming potential (100yrs)[3]	g CO_2 eq	2,770E-02	1,024E-01	7,578E+00	7,708E+00	1,696E-01	2,962E-01	8,174E+00
Ozone depleting potential (20yrs)	g CFC-11 eq	1,455E-08	4,261E-09	1,109E-06	1,128E-06	2,482E-08	1,520E-08	1,168E-06
Formation of ground level ozone	g C_2H_4 eq	1,302E-05	5,284E-06	2,721E-03	2,740E-03	6,027E-05	1,745E-04	2,974E-03
Emissions to air which contribute most to the environmental impact categories								
Carbon dioxide, fossil	g	2,538E-02	1,009E-01	6,849E+00	6,975E+00	1,534E-01	2,386E-01	7,367E+00
Methane, fossil	g	8,094E-05	4,201E-05	1,794E-02	1,806E-02	3,973E-04	5,148E-04	1,897E-02
Dinitrogen monoxide	g	5,877E-07	1,078E-06	2,694E-04	2,711E-04	5,964E-06	7,042E-06	2,841E-04
Carbon monoxide, fossil	g	3,559E-05	5,448E-05	5,582E-02	5,591E-02	1,230E-03	2,714E-03	5,985E-02
Methane, chlorodifluoro-, HCFC-22	g	5,045E-10	1,398E-10	3,319E-06	3,320E-06	7,304E-08	2,216E-09	3,395E-06
Methane, bromotrifluoro-, Halon 1301	g	1,268E-09	3,698E-10	2,741E-08	2,905E-08	6,391E-10	8,851E-10	3,057E-08
Methane, bromochlorodifluoro-, Halon 1211	g	1,267E-10	3,429E-11	2,441E-08	2,458E-08	5,407E-10	5,831E-10	2,570E-08
Methane, tetrachloro-, CFC-10	g	2,576E-11	4,039E-11	1,114E-07	1,114E-07	2,452E-09	2,885E-10	1,142E-07
Sulfur dioxide	g	1,629E-04	4,506E-05	1,889E-02	1,909E-02	4,201E-04	1,923E-03	2,144E-02
Nitrogen oxides	g	8,648E-05	1,174E-04	1,984E-02	2,005E-02	4,410E-04	7,310E-04	2,122E-02
Ammonia	g	5,506E-07	1,239E-06	3,693E-04	3,711E-04	8,165E-06	4,542E-05	4,247E-04
Hydrogen chloride	g	6,905E-07	3,483E-07	4,326E-04	4,336E-04	9,540E-06	1,082E-05	4,540E-04
Ethane	g	1,149E-06	2,860E-07	1,193E-04	1,208E-04	2,657E-06	3,287E-06	1,267E-04
Ethene	g	1,111E-07	4,571E-08	4,888E-05	4,904E-05	1,079E-06	1,341E-06	5,146E-05
Pentane	g	2,757E-06	6,660E-07	7,543E-05	7,885E-05	1,735E-06	2,487E-06	8,308E-05
Butane	g	2,227E-06	5,294E-07	5,520E-05	5,796E-05	1,275E-06	1,852E-06	6,109E-05
Propene	g	1,016E-07	2,671E-08	1,815E-05	1,827E-05	4,020E-07	1,938E-07	1,887E-05
Methane, tetrafluoro-, CFC-14	g	3,020E-09	7,627E-09	7,620E-06	7,631E-06	1,679E-07	3,173E-06	1,097E-05
Emissions to water which contribute most to the environmental impact categories								
Phosphate	g	2,881E-05	2,743E-05	1,344E-02	1,349E-02	2,968E-04	2,224E-03	1,601E-02
COD, Chemical Oxygen Demand	g	5,185E-04	3,945E-04	2,662E-02	2,753E-02	6,057E-04	8,497E-04	2,899E-02
Nitrate	g	7,908E-06	3,969E-06	3,080E-03	3,092E-03	6,802E-05	2,224E-04	3,382E-03
Emissions of radioactive isotopes								
C-14	KBq	2,112E-07	2,303E-07	4,584E-05	4,628E-05	1,018E-06	1,784E-06	4,908E-05
Rn-222	KBq	3,825E-03	3,944E-03	8,327E-01	8,405E-01	1,849E-02	3,368E-02	8,927E-01
Kr-85	KBq	8,249E-08	3,768E-08	1,341E-05	1,353E-05	2,976E-07	2,892E-07	1,411E-05
Emissions of biogenic carbon dioxide								
Carbon dioxide, biogenic	g	3,331E-04	1,529E-04	9,087E-02	9,136E-02	2,010E-03	1,565E-02	1,090E-01

[3] Biogenic carbon dioxide emissions, are included in the Global Warming Potential impact category

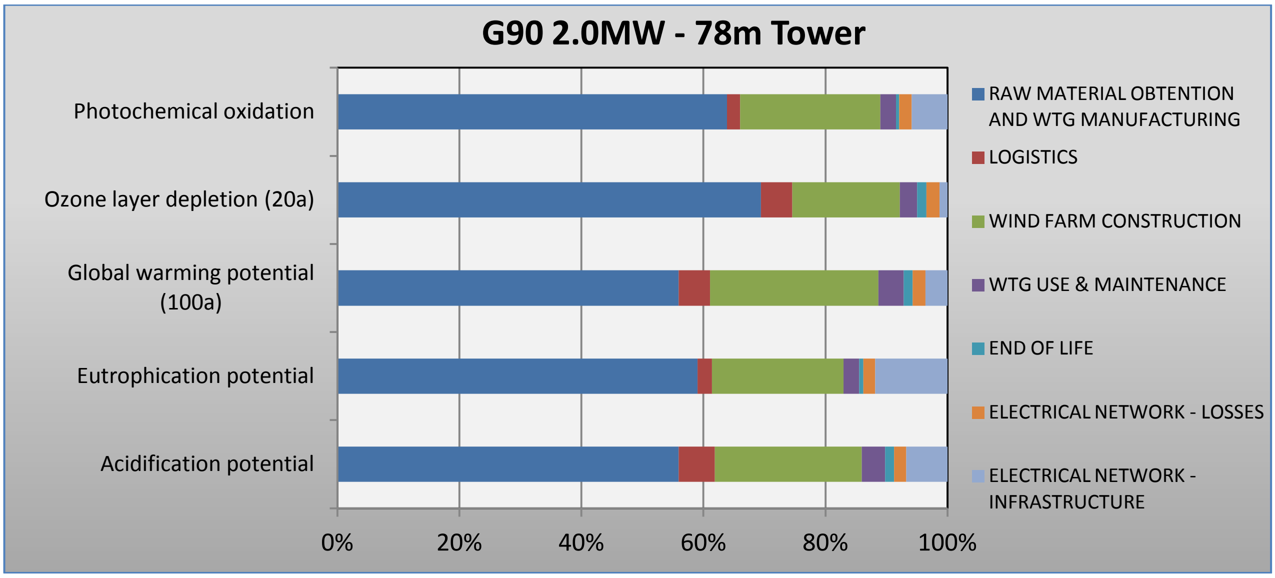
ECO-PROFILE POLLUTANT EMISSIONS	UNIT	IEC II Wind Class - European Wind Farm - 78 m Tower 1 KWh electricity generated and distributed to a 132 KV customer						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Emissions of toxic substances								
Particulates, <2,5 um to air	g	8,305E-06	1,125E-05	5,509E-03	5,528E-03	1,216E-04	2,375E-04	5,887E-03
Particulates, >10 um to air	g	9,236E-06	9,072E-06	1,133E-02	1,135E-02	2,497E-04	4,415E-04	1,204E-02
Particulates, >2,5 um, and <10 um to air	g	3,333E-06	5,410E-06	7,919E-03	7,928E-03	1,744E-04	3,545E-04	8,457E-03
PAH, polycyclic aromatic hydrocarbons to air	g	3,312E-09	3,992E-09	4,291E-06	4,298E-06	9,455E-08	1,144E-06	5,536E-06
PAH, polycyclic aromatic hydrocarbons to water	g	1,368E-08	2,731E-09	1,128E-06	1,144E-06	2,517E-08	9,476E-09	1,179E-06
Arsenic to air	g	5,302E-09	3,114E-09	7,305E-06	7,314E-06	1,609E-07	2,069E-06	9,544E-06
Cadmium to air	g	2,715E-09	1,170E-09	2,020E-06	2,024E-06	4,453E-08	7,056E-07	2,774E-06
Dioxins to air	g	6,051E-15	8,249E-14	1,763E-11	1,772E-11	3,897E-13	5,925E-13	1,870E-11
Emissions of oil to water and ground								
Oils, unspecified to water	g	1,587E-04	2,446E-05	2,108E-03	2,291E-03	5,041E-05	9,039E-05	2,432E-03
Oils, unspecified to soil	g	1,676E-04	2,466E-05	2,042E-03	2,234E-03	4,915E-05	9,367E-05	2,377E-03

ECO-PROFILE WASTE & MATERIAL SUBJECT TO RECYCLING	UNIT	IEC II Wind Class - European Wind Farm - 78 m Tower 1 KWh electricity generated and distributed to a 132 KV customer						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Hazardous waste - Non-radioactive								
Hazardous waste - To incineration	g	-	2,435E-02	9,196E-03	3,355E-02	7,381E-04	1,838E-03	3,612E-02
Hazardous waste - Radioactive								
Volume for deposit of low-active radioactive waste	m3	2,428E-13	2,498E-13	5,259E-11	5,308E-11	1,168E-12	2,102E-12	5,635E-11
Volume for deposit of radioactive waste	m3	6,105E-14	5,654E-14	1,304E-11	1,316E-11	2,896E-13	5,328E-13	1,398E-11
Other waste								
Non-hazardous waste - To landfill	g	-	-	7,648E+00	7,648E+00	1,682E-01	3,752E-02	7,853E+00
Non-hazardous waste - To incineration	g	-	-	1,935E-04	1,935E-04	4,258E-06	8,610E-03	8,808E-03
Non-hazardous waste - To recycling	g	-	-	1,905E+00	1,905E+00	4,190E-02	7,903E-02	2,026E+00
Inert waste (Rock, sand etc) – To inert landfill	g	-	-	1,124E+01	1,124E+01	2,472E-01	-	1,149E+01

The list of the reported emissions, are the ones whose contribution to the total environmental impact is higher than a 0.5% for any of the environmental impact categories declared.

3.4. HOT SPOT ANALYSIS AND CONCLUSIONS

The following figure shows the life cycle environmental impacts of the energy generated by a G90 wind turbine generator and thereafter distributed to a customer. The results have been divided between the main life cycle stages and are represented separately for the five environmental impact categories assessed.



As shown in the figure above, the environmental impacts are mainly caused in two of the stages within the energy life cycle, which are the WTG manufacturing and the construction of the wind farm infrastructures.

When we look at the average environmental impact taking into account the 5 analyzed categories, nearly the 61% of the impacts are caused in the WTG manufacturing stage. These are logical results, since a wind turbine does not consume any fossil fuel during its operation as the conventional energy sources do, so the main environmental aspects of this technology are related to the manufacturing of its infrastructure. This is mostly caused by the raw materials needed to manufacture all the steel parts of the WTG and the subsequent machining phases. The most critical component in this phase is the tower by far. The blades, the gearbox, the main shaft and the rest of the parts that shape the rotor, have also a significant environmental impact.

During the wind farm construction stage, the 23% of the impacts are caused in average. The most relevant environmental aspects for this phase are related to the materials which compose the foundation (mainly concrete and steel), followed by the underground wiring and the connection lines needed to reach the main electrical network. Finally, the environmental contribution of the aggregates used for the terrain adaptation (road accesses, platforms…) is also remarkable.

Another life cycle stage to be considered is the one associated to the electricity transmission infrastructures, although the environmental impacts caused in this phase are the 6% in average, much lower than in the previously mentioned life cycle stages. These impacts are primarily caused by the raw material consumption for the high voltage overhead lines construction (copper, aluminum, steel, polymers).

The rest of the modules as for example use and maintenance, end of life, electrical losses in the network and logistics, have a minor contribution to the life cycle environmental impacts of the generated and distributed energy using Gamesa G90 2.0 MW wind turbines. For example, the logistics stage has a contribution around the 4% while the other stages have a contribution lower than a 3% each.

4. ADDITIONAL ENVIRONMENTAL INFORMATION

4.1. IMPACT ON BIODIVERSITY

Prior to every wind farm commissioning, diverse biodiversity studies are conducted in order to become acquainted of the potential impact that the projected installations could cause towards the local existing flora and fauna.

Biodiversity Studies

	2012	2011	2009
Development phase			
Preliminary environmental impact assessments	1	10	17
Archaeology	-	1	-
Environmental imp. assessment	12	15	25
Bird fauna and bats	15	33	7
Noise	1	15	-
Specific studies	9	31	23
Construction phase			
Environmental monitoring	5	1	7
Archeological monitoring	-	1	-
Other	-	3	-
Operations phase			
Environmental monitoring	7	19	7
Other	-	6	14
TOTAL	50	135	99

Source: Gamesa sustainability report 2012, http://www.gamesacorp.com

4.1.1. FLORA

The vegetation may be affected by the need of land preparation for the 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 start the construction, to avoid a physical repercussion higher than the strictly necessary.
- Proper gathering of the extracted soil 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, potentially polluting 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 of the embedment of concrete footings, for the conditioning and landscape restoration.
- 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, the layout is rethought 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 kind of impact.

- During the execution of the works for laying out the 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 outer line installation, 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, the installation is relocated.
- 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 behavior. Besides, the risk of collision of birds on the blades is reduced since they quickly become accustomed to the turbines.

4.2. LAND USE

The wind farms chosen for the land use analysis are several of the parks with 2.0 MW wind turbines in which Gamesa holds the promotion of the wind farms. Although all analyzed sites are located in Spain, the techniques used for the site construction works can be considered representative for a European wind farm case, according to experts in civil engineering from Gamesa. We used the average size of a G90 2.0 MW Gamesa wind farms in Europe, which is 28.5 MW of installed capacity.

4.2.1. DESCRIPTION OF LAND USE

An analysis of soil condition is conducted before and after the wind farm installation is made. Below, the land use description of the selected wind farms is shown.

4.2.1.1. LOS LIRIOS

The wind farm "Los Lirios" is located in the province of Huelva at the town of San Silvestre de Guzmán, in the areas known as Los Lirios, Cabeza del Llano, Los Llanos, Cabeza del Rato, Loma de la Carnicera and Colmenar de Nuestra Señora. It lies west of the region of Andévalo, and is surrounded by Villanueva de Castillejos to the north, Villablanca to the south, Sanlucar de Guadiana to the northwest and Portugal to the west. The wind farm is composed of 24 wind turbines, accounting to a total power of 48 MW.

4.2.1.2. ALTO DE LA DEGOLLADA

The complex “Alto de la Degollada” is located at the township of Castrojeriz and Los Balbases, (Burgos). The wind farm has 25 wind turbines with a total installed power of 50 Mw, arranged in three rows of NW-SE direction. The nearest population center is Vallunquera, 1.7 miles east of the wind farm. “Pedrosa del Principe” is also near, which is 2.7 km away from the nearest wind generator. The wind farm is located at a distance of approximately 2.5 km of the site of community interest "Riberas de la subcuenca del río Pisuerga”.

4.2.1.3. BARCHÍN DEL HOYO

The wind farm of Barchín, located in the townships of Alcala de la Vega and Algarra, in the province of Cuenca, consists of 14 2.0 MW turbines with a capacity to deliver up to 28 MW. Located in the municipality of Barchín del Hoyo (Cuenca), the turbines are held on tapered tubular steel towers of 78 meters high, with triple rotor 45 meter radius. Each turbine is fitted inside the mast 2,100 kVA transformer. The turbines will be connected to the collecting system using HPREZ1 conductors 12/20 kV buried in a trench of 1.20 m depth with 400 mm^2 sections.

4.2.1.4 LES FORQUES II

The wind farm of Les Forques II, located in Catalonia, in the place known as "Les Vilars" lines the top of the left side ditch Fores (Obaga the Comet). The access road is a path out of the T-222 to about 1.250 m in the township of Passanant. It consists of 6 2.0 MW WTGs, with a total installed power of 12 MW. Data include the access roads, internal roads, maneuvering areas and transformer substation. The total balance in the earthmoving is 16.727 m^2. Predominantly agricultural activities occupy most of the surrounding land.

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 m^2.

For the particular case of the “Les Forques II” wind farm, land use data are not shown here because there are no data specified in the respective EIS (Environmental Impact Study). These studies are conducted by specialized environmental consultancies in the vicinities of the construction site. Because of this, there are small format and content differences between one study and another, depending on the location and the local applicable regulations.

4.2.2.1. PREVIOUS LAND USE

In the table below, the land use of the mentioned wind farms prior to their installation is represented.

BEFORE WIND FARM CONSTRUCTION				
BEFORE	**Los Lirios**	**Barchín**	**Alto de la Degollada**	**Total**
Artificial areas	0	0	0	**0**
Farming areas	160.047	41.600	151.400	**353.047**
Forest and semi-natural areas	18.467	22.400	0	**40.867**
Wetland	0	0	0	**0**
Water	0	0	0	**0**
Total	**178.514**	**64.000**	**151.400**	**393.914**

4.2.2.2. LAND USE AFTER THE ERECTION OF THE WIND FARM

In the table below is represented the occupation of land, with the areas strictly occupied by the selected wind farms after installing them. The data extracted from the projects are 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 connections and the control building.

AFTER WIND FARM CONSTRUCTION				
AFTER	**Los Lirios**	**Barchín**	**Alto de la Degollada**	**Total**
Artificial areas	138.745	64.000	151.400	**354.145**
Farming areas	21.302	0	0	**21.302**
Forest and semi-natural areas	18.467	0	0	**18.467**
Wetland	0	0	0	**0**
Water	0	0	0	**0**
Total	**178.514**	**64.000**	**151.400**	**393.914**

4.2.3. NUMBER OF YEARS OF OCCUPATION

YEARS OF OCCUPATION		
Wind farm	**Start of the activity**	**Number of years until 2015**
Los Lirios	2010	5
Alto de la Degollada	2010	5
Barchín del Hoyo	2011	4

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 four reference wind sites mentioned are composed of the following infrastructures:

- Towers
- Foundations y tower bases
- Roads

4.3. ENVIRONMENTAL RISKS

Gamesa environmental risk analysis is performed at different stages of projects according to the criteria of the Standard ISO 15008 - 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.

In addition, 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:

- Oil spill
- Accidental fire or explosions
- Affection to flora
- Affection to fauna
- Affection to archeological remains
- Concrete spill
- Spill of hazardous or toxic substances

4.3.1. RISK INVENTORY

4.3.1.1. TRANSPORT

During the logistics stage road accidents may occur, originating fuel or oil losses or even starting a fire. Uncontrolled fires can emit a considerable amount of polluting substances to air and additionally, the oil and fuel losses could lead to local impacts on water and environmentally sensitive areas.

4.3.1.2. CONSTRUCTION AND DECOMMISIONING

While the wind farm is being constructed, the cranes and other vehicles oriented to component assemblage can experience break downs, potentially provoking oil and fuel losses or causing fire risks. A fire could also be started during the different wind turbine component manufacturing stage. However, fire emergency plans and appropriate extinguishing tools are available in all Gamesa factories and wind farms, thus reducing the identified risks.

4.3.1.3. OPERATION

In the operation phase, there is also fire risk in the nacelle electrical components or in the transformer which could derive in oil combustion. Besides, during maintenance activities, lubricating and/or hydraulic oils could be accidentally spilled. The environmental impact produced by these leakages is included in the transport risks previously mentioned.

4.3.2. RESULTS

In the following table such impacts are quantified. In the right column, the emissions under normal conditions are represented, allowing the comparison between the different situations already explained above.

Potential risks	Substances emitted to air	Substances emitted to soil	Potential emissions at incidents [Core] (g/kWh)	Potential emissions at incidents [Core - Infrastructure] (g/kWh)	Emissions at normal conditions (g/kWh)
Oil spills (transport)	-	Diesel	$<10^{-6}$	10^{-5}	10^{-3}
Fires at Nacelle Components	CO_2	-	10^{-6}	0	10^{1}

In conclusion, as can be deduced from the results in the table, the impact produced by the potential risks is considerably lower than those produced in normal conditions.

4.4. ELECTROMAGNETIC FIELDS

The international Commission on Non-Ionising Radiation Protection (ICNIRP), an independent body consisting of international experts, has published some 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 500μT for working environments and a limit of 100μT for a general environment.

In addition and coming from the EMC Directive (2004/108/EC) (Electromagnetic Compatibility Directive), it is worth noting that the EN 62311 standard and the EN 62479 standard (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 consideration in the technical specifications of the machine, whose design satisfies these requirements. It can be said that although electromagnetic fields are generated during the WTG operation, they will not cause harm to human health, being lower than those issued by the ICNIRP recommendations.

4.5. NOISE

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

Depending on the WTG model and the tower height, up to five low noise operation modes exist which allow a noise level reduction varying the rotation speed and the pitch angle. Nevertheless, under low noise operation modes the energy generation is reduced. According to the location of the wind farm, the noise produced by the wind turbine generators can vary.

The Gamesa G90 WTG working conditions are comprised between 3 m/s and 25 m/s. This wind turbine produces a maximum noise of 100 decibels (800 Hz) within the nacelle, in the most unfavorable conditions. The already mentioned noise level is reached when the wind speed is among 7 and 12 m/s. In this case, 100 decibels is not an alarming noise level given the fact that farther away than 300 meters the noise perception is greatly reduced. Since wind farms are usually located in unoccupied areas, they will not significantly affect surrounding population.

The current trend in the wind industry is to manufacture increasingly bigger machines. These higher power models allow their installation in low wind areas, because their rotation speed is lower. An increase on the tower height also provokes a reduction on the sound pressure. From this fact it can be deduced that future wind turbine generators will tend to be even more silent.

4.5.1 NOISE CALCULATION

There are two international standards that establish noise measurement procedure and noise level 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 a WTG

Based on these standards, Gamesa Corporación Tecnológica defines the noise levels of its G90 2.0 MW platform for standard configuration and low temperature configuration, which only produce aerodynamic noise. The noise generated by a wind turbine generator in its high temperature version is defined based on the other mentioned configurations, with an increase on the decibels emitted by the machine.

The G90 emitted noise values are within the normal values for the wind industry. It is also noteworthy that wind farms are located in uninhabited areas. Within distances greater than 300 meters, the noise level is greatly reduced and is considered negligible, being lower than the ambient noise threshold in nature, wind, etc.

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 out by Gorka Benito Alonso, independent approved verifier by the international EPD® System, who 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 document "General Programme Instructions for the EPD System", 2015-05-11 ver. 2.5, published by the International EPD System and PCR UN CPC 171 & 173: Electricity, Steam, and Hot and Cold Water, 2015-02-05 ver. 3.0.

The verifier Gorka Benito Alonso has been approved by the International EPD® System to verify Environmental Product Declarations, EPD.

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).

EPD®

Gamesa

5.2.4. INFORMATION ON VERIFICATION

<table>
<tr><th colspan="3">EPD PROGRAMME AND PROGRAMME OPERATOR</th></tr>
<tr><td colspan="3">The International EPD® System
Programme operator: EPD International AB
Valhallavägen 81
SE-114 27 Stockholm - Sweden</td></tr>
<tr><th colspan="3">INDEPENDENT VERIFICATION OF THE DECLARATION AND DATA, ACCORDING TO ISO 14025:2006</th></tr>
<tr><td>☐ EPD Process certification

☑ EPD Verification</td><td>Third party verifier:

Gorka Benito Alonso
IK Ingenieria
g.benito@ik-ingenieria.com</td><td>Approved by:

The International EPD® System</td></tr>
<tr><th colspan="3">PRODUCT CATEGORY RULES</th></tr>
<tr><td colspan="3">PCR 2007:08, Version 3.0,
CPC 171 & 173: Electricity, Steam, and Hot/Cold Water Generation and Distribution
Date 2015-02-05 / Valid until 2019-02-05</td></tr>
<tr><th colspan="3">PCR REVIEW</th></tr>
<tr><td colspan="3">Product Category Rules (PCR) review was conducted by “The Technical Committee of the International EPD® System”. Chair: Massimo Marino

Contact via: info@environdec.com

Full list of TC members available on www.environdec.com/TC</td></tr>
</table>

VALID UNTIL	REGISTER NUMBER
2019 - 04 - 05	**S-P-00452**

<table>
<tr><th>GAMESA CORPORACIÓN TECNOLÓGICA</th></tr>
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</table>

6. LINKS AND REFERENCES

Additional information about Gamesa Corporación Tecnológica:

www.gamesacorp.com

Additional information about the International EPD® System:

www.environdec.com

- General programme instructions (Version 2.5) 2015-05-11: http://www.environdec.com/Documents/GPI/General%20Programme%20Instructions%20version%202.5.pdf

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

Data base used for the LCA:

- EcoInvent v2.2 database, published by the Swiss Centre for Life Cycle Inventories http://www.ecoinvent.org

Other references:

- Iberdrola – www.iberdrola.es
- Red eléctrica española – www.ree.es
- Comisión Nacional de la Energía – www.cne.es
- Eurelectric – www.eurelectric.org
- Réseau de transport d'électricité – www.rte-france.com
- Électricité Réseau Distribution France – www.erdfdistribution.fr
- Terna Group - www.terna.it
- PSE Operator – www.pse-operator.pl
- Council of European Energy Regulators (CEER) – www.energy-regulators.eu
- Windar Renewables - www.windar-renovables.es
- Abb – www.abb.com
- Worldsteel Association – www.worldsteel.com
- Copper Development Association – www.copper.org
- International Aluminum Institute - www.world-aluminium.org
- European Steel Association - www.eurofer.org
- Censa – www.censa.es
- General cable – www.generalcable.es
- Asociación empresarial eólica – www.aeeolica.org
- European Wind Energy Association – www.ewea.org
- German Wind Energy Institute – www.dewi.de
- IEC 61400-1 Wind turbines - Design requirements
- CML 2001 IA Characterisation Factors – Institute of environmental Science - Leiden University - http://cml.leiden.edu/software/data-cmlia.html#downloads

7. ACRONYMS

- EPD: Environmental Product Declaration
- PCR: Product Category Rules
- IEC: International Electrotechnical Commission
- LCA: Life Cycle Assessment
- ISO: International Organization for Standardization
- GPI: General Programme Instructions
- GCT: Gamesa Corporation