ENVIRONMENTAL PRODUCT DECLARATION

Gamesa

Electricity from:

European G114-2.0MW On-shore Wind Farm

EPD®

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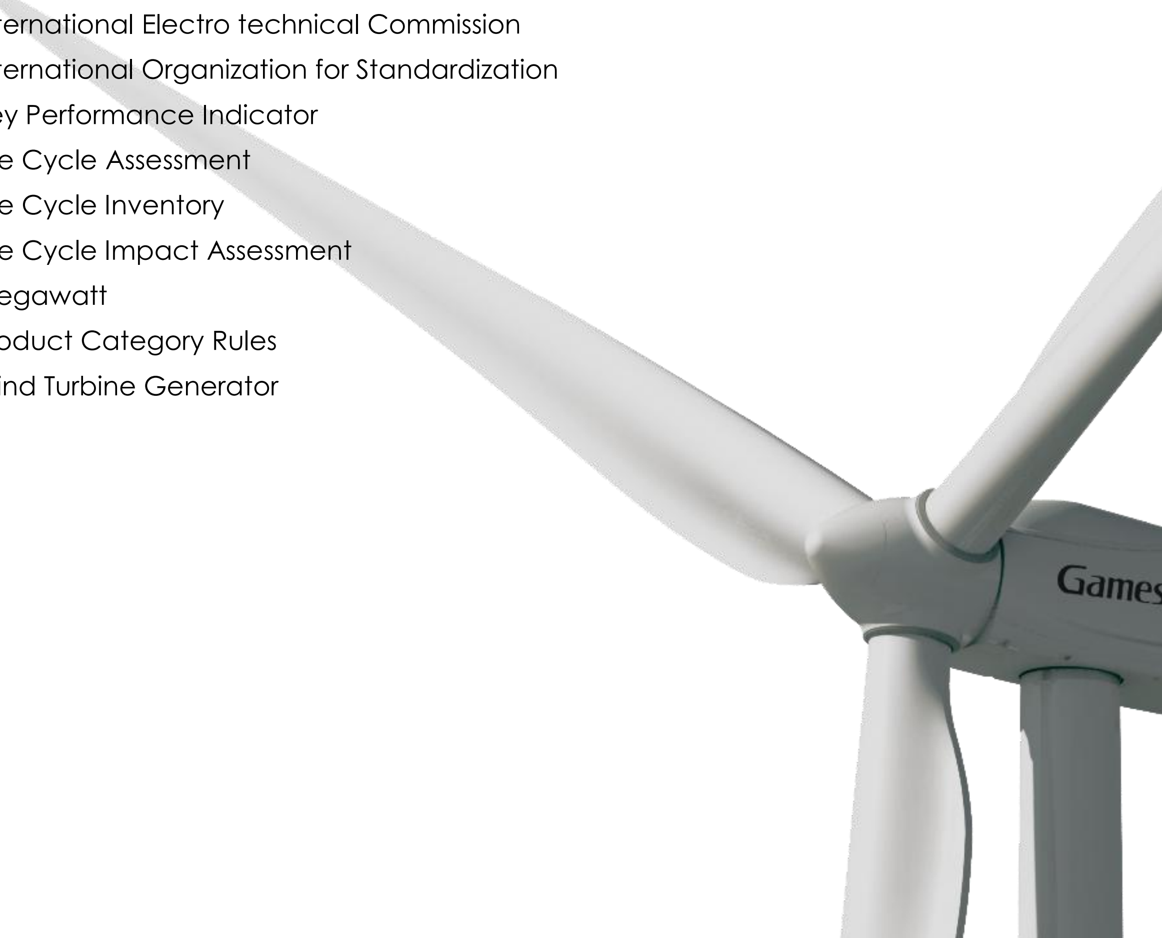
CONTENT

1. INTRODUCTION ... 1
1.1 DECLARED PRODUCT ... 1
1.2 ENVIRONMENTAL DECLARATION AND THE EPD SYSTEM ... 1
1.3 GAMESA, LCA AND EPD ... 2
2. THE COMPANY AND THE PRODUCT ... 3
2.1 GAMESA CORPORACIÓN TECNOLÓGICA ... 3
2.2 PRODUCT SYSTEM DESCRIPTION ... 3
2.2.1 The GAMESA G114-2.0 MW Wind Turbine Generator ... 4
2.2.2 The wind farm ... 6
2.2.3 Electricity transmission and distribution infrastructure ... 7
2.2.4 Wind energy life cycle ... 8
3. ENVIRONMENTAL PERFORMANCE BASED ON LCA ... 10
3.1 LIFE CYCLE ASSESSMENT METHODOLOGY ... 10
3.2 SYSTEM BOUNDARIES AND DATA SOURCES ... 10
3.2.1 Core – Infrastructure ... 12
3.2.2 Core – Process ... 14
3.2.3 Upstream ... 15
3.2.4 Downstream ... 15
3.3 ECO-PROFILE ... 16
3.3.1 Scenario A: IEC II Wind class – European Wind Farm - 80m Tower ... 17
3.3.2 Scenario B: IEC II Wind class – European Wind Farm - 93m Tower ... 20
3.4 HOT SPOT ANALYSIS AND CONCLUSIONS ... 23
4. ADDITIONAL ENVIRONMENTAL IMPACT ... 25
4.1 IMPACT ON BIODIVERSITY ... 25
4.1.1 Flora ... 25
4.1.2 Fauna ... 26
4.1.3 Analysis of protected or restored habitat ... 27
4.1.4 Biodiversity studies ... 27
4.2 LAND USE ... 28
4.2.1 Description of land use ... 28
4.2.2 Land use – Corine Land Cover classification ... 29
4.2.3 Number of years of occupation ... 30
4.2.4 Description of the infrastructure in the occupied areas ... 30
4.3 ENVIRONMENTAL RISKS ... 30
4.4 ELECTROMAGNETIC FIELDS ... 31

4.5 NOISE 32
4.5.1 Noise calculation 32
4.6 VISUAL IMPACT 32
5. CERTIFICATION BODY AND MANDATORY STATEMENTS 33
5.1 INFORMATION FROM THE CERTIFICATION BODY 33
5.2 MANDATORY STATEMENTS 33
5.2.1 General 33
5.2.2 Life cycle stages omitted 33
5.2.3 Means of obtaining explanatory materials 33
5.2.4 Information on verification 34
6. LINKS AND REFERENCES 35

ACRONYMS AND ABBREVIATIONS

AEP Annual Energy Production
B2B Business to Business
CoE Cost of Energy
EIS Environmental Impact Study
EPD Environmental Product Declaration
GCT Gamesa Corporación Tecnológica
GPI General Programme Instructions
IEC International Electro technical Commission
ISO International Organization for Standardization
KPI Key Performance Indicator
LCA Life Cycle Assessment
LCI Life Cycle Inventory
LCIA Life Cycle Impact Assessment
MW Megawatt
PCR Product Category Rules
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 on-shore wind farm of Gamesa G114 - 2.0 MW wind turbine generators, located in a European scenario and operating under medium wind conditions (IEC IIA), and then distributed to a European consumer.

Due to the relevance of the "tower" component within the final environmental results, a sensitivity analysis has been conducted including a variation of this component. The baseline scenario includes 80 meters high towers, while the alternative scenario has been calculated using 93 meters high towers. All the final results are separately calculated for these two different scenarios.

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 on-shore wind farm of Gamesa G114 - 2.0 MW wind turbine generators, located on a European scenario and operating under medium wind conditions (IEC IIA) and thereafter distributed to a European power transmission grid."

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 CO2 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 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).

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

- Product Category Rules, PCR 2007:08 version 2.02 CPC 171 & 173: Electricity, Steam, and Hot and Cold Water Generation and Distribution.
- General Programme Instructions for Environmental Product Declarations, Version 2.01.
- ISO 14025 - Type III environmental declarations.
- 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 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 wind farm

1.3 GAMESA, LCA AND EPD

Gamesa Corporación Tecnológica (hereafter 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, 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 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 G114 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 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.

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 average Gamesa on-shore wind farm composed of 2.0MW WTGs, located on a European scenario operating under medium wind conditions (IEC IIA). The average total installed capacity for this kind of wind farms is 30 MW, so that the baseline system is assumed to be composed of 15 Gamesa G114 WTGs of 2.0 MW unitary power each.

Gamesa is able to supply different kind of towers, seeking a right placement of the rotor at the height which optimizes the energy harvested. Given the fact that the height of the tower has an important relevance in the final environmental results, a sensitivity analysis has been conducted including a variation of this component. The baseline scenario includes 80 meters high towers, while the alternative scenario has been calculated using 93 meters high towers. All the final results are presented for these two different scenarios.

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 infrastructure needed for electrical transmission and distribution until the final customer of the electricity generated 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 G114-2.0 MW Wind Turbine Generator

The Gamesa G114-2.0MW wind turbine is an evolution of the previous Gamesa 2.0MW platform models, and 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 until 30 years of operation. Furthermore, in the previous LCA conducted by GCT on the WTG model G90 2.0 MW, a sensitivity analysis was made taking into account the environmental effect of enhancing the life of a wind farm. This LCA is publicly available in the GCT website. More info on Gamesas's life extension program is available in the following link:

http://www.gamesacorp.com/en/products-and-services/services/life-extension.html

Figure 1. - G114-2.0MW Wind Turbine Generator

The G114-2.0MW is a 2.0 MW rated power turbine, with a three-blade rotor. It has a rotor diameter of 114 m, and a swept area of 10,207 m2. It is supported by a tapered tower with 3 different tower heights: 80, 93 and 125. More options could be available on demand. For the present LCA, two life cycle models have been created. The first one includes the 80m tower yet the second model includes the 93m tower. This modelization allows us to know the environmental sensibility of changing the tower component. The picture below shows the G114 power curve compared to other platform models.

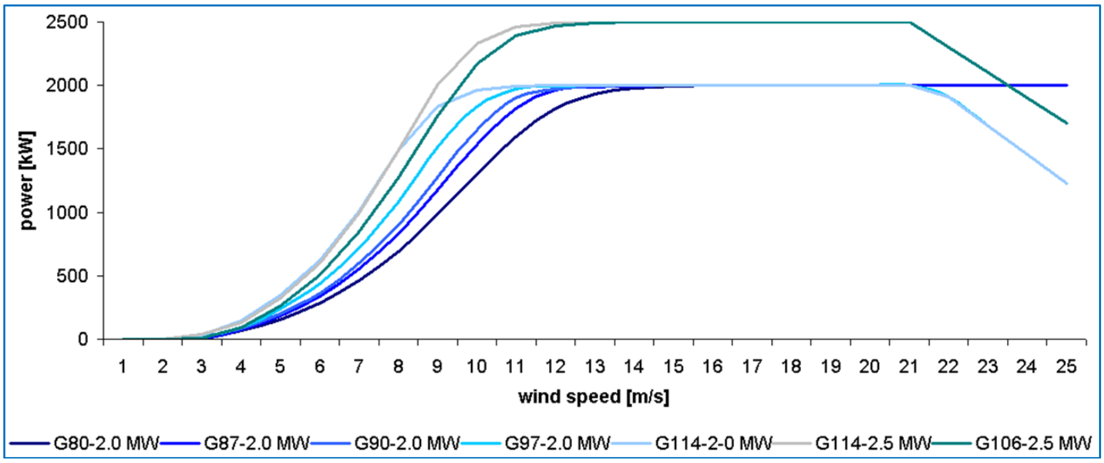


Figure 2.- Gamesa 2.0/2.5 MW platform power curves

Some general advantages of G114-2.0MW wind turbine:

- Big new 114 m rotor for a relatively small 2.0 MW nominal power ⇨ Highest capacity factor in the market.
- Improved CoE and increased efficiency and profitability in low-wind sites.
- New 56m blade with advanced aerodynamic design for highest efficiency & lowest noise.
- Proven technologies from Gamesa 2.0 MW Platform.
- Exhaustive validation and certification campaign with 2 prototypes running, one in Alaiz, Spain (50 Hz) and one in Lubbock, USA (60 Hz).

The Gamesa G114-2.0MW 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%. Gamesa 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.

Some of the Gamesa 2.0-2.5MW platform advantages are listed below:

- Most versatile platform in the market: 6 different rotors: G80, G87, G90, G97, G106, G114, 2 nominal powers (2 – 2.5 MW), several tower heights (78m, 80, 90, 93, 120, 125…).
- Platform with proven technologies and more than 10 years field experience with more than 17 GW installed in more than 30 countries.
- Availability figures exceeding 98%.
- Continuous evolution to larger rotors and higher nominal power, to be a benchmark in the market with the highest capacity factors and reduced CoE.
- Pitch and variable speed to maximize energy production.
- Blade profiles optimized for maximum output and low noise.
- Technological solutions to ensure compliance with the main requirements of international networking.
- Customized solutions for specific grid code requirements.
- Specific configurations for demanding environments: High Dust, High Altitude, High Corrosion, High Temperature, Low Temperature.
- GAMESA active yaw system to ensure optimal adaptation to complex terrain orography.
- Aerodynamic design and GAMESA NRS ® control to minimize noise emissions.
- GAMESA WindNet ®: control and monitoring system access remote Web.
- GAMESA SMP own predictive maintenance system.
- De-icing system option available.

	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.

Table 1.- Gamesa 2.0/2.5 MW platform features

2.2.2 The wind farm

Since GCT 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 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 make a generic model representative of a European average wind site from the actual data known from Gamesa 2.0 MW wind farms installed.

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 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 location of an average Gamesa 2.0 MW wind farm, four different scenarios have been analyzed, including the four European countries where Gamesa has installed more power with these kind of machines. The countries analyzed are Spain, France, Poland and Italy and are considered representative of the European situation of Gamesa 2.0 MW clients, as these countries represent the 81,76% of the power that GCT has installed using this platform. Furthermore, in the previous LCA conducted by Gamesa on the WTG model G90 2.0 MW, a sensitivity analysis was made taking into account the environmental effect of installing a park farther or closer to Gamesa's manufacturing installations. This LCA is publicly available in the GCT website.

Regarding the size of the wind farm, we have assigned the average requirement of materials and building 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 many WTGs (i.e. transformer substation, internal wiring, connection infrastructure to the electrical network, road conditioning to allow access to machinery…), the average wind park size of 30 MW installed has been used as baseline.

Finally, for the data needed to assess the environmental impact related to the building works of the emplacement, data of different Spanish 2.0 MW construction sites has been used.

WIND FARM	LOCATION	COUNTRY	NUMBER OF WTG	INSTALLED CAPACITY
Alto de la degollada	Castrojeriz	Spain	25	50 MW
Los Lirios	San Silvestre de Guzmán	Spain	24	48 MW
Barchín	Barchín del Hoyo	Spain	14	28 MW
Les Forques II	Passanant	Spain	6	12 MW

Table 2.- 2.0MW Wind Farms

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.

2.2.3 Electricity transmission and distribution infrastructure

Once the wind is converted into electricity by the G114 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 airlines, depend on the voltage level of the electricity being transported in each steps, from 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.

The WTG generates low voltage electricity (690V). This voltage is increased in the transformer located inside the nacelle reaching medium voltage level to minimize electricity losses (30KV assumed for the analysis). At the exit of the wind farm there is another transformer station allowing the delivery of high voltage electricity to the general network. An average of European electricity losses has been assumed for the analysis, according to specific data from Eurelectric, so the voltage level of the delivered electricity has been considered as a mix of low and medium voltage consumers, depending on each European country.

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

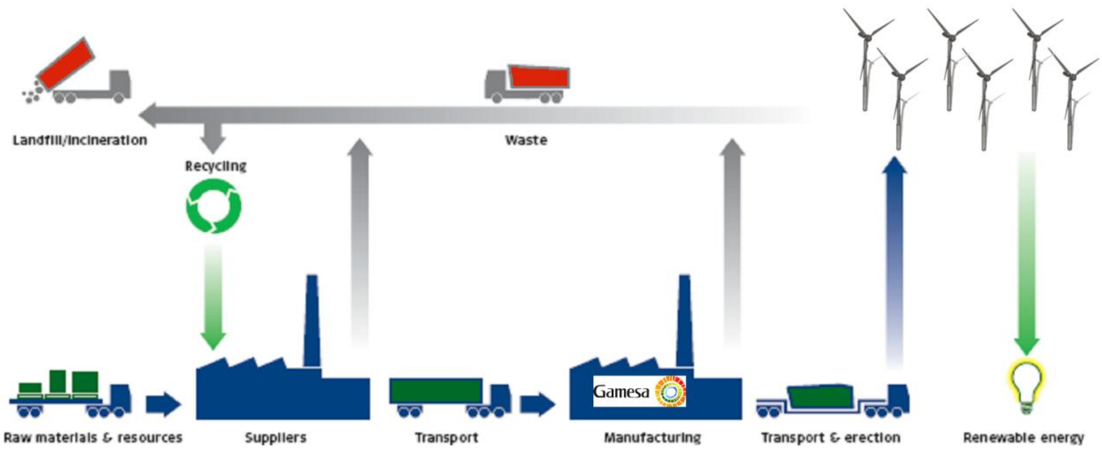


Figure 3.-Wind energy life cycle

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. As shown in the mentioned figure, the life cycle of energy is a complex system in which it is necessary to clearly establish the boundaries between phases to avoid mistakes. Following the recommendations of the PCR, the energy life cycle has been divided into three main modules, core module, up-stream module and down-stream 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 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 G114 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 4. - G114-2.0MW 60 Hz prototype installed in Lubbock, USA.

2.2.4.2 Up-stream 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 Down-stream 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 (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 G114 - 2.0 MW wind turbine generators, located on a European scenario and operating under medium wind conditions (IEC IIA) and thereafter distributed to a European power transmission grid.

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.

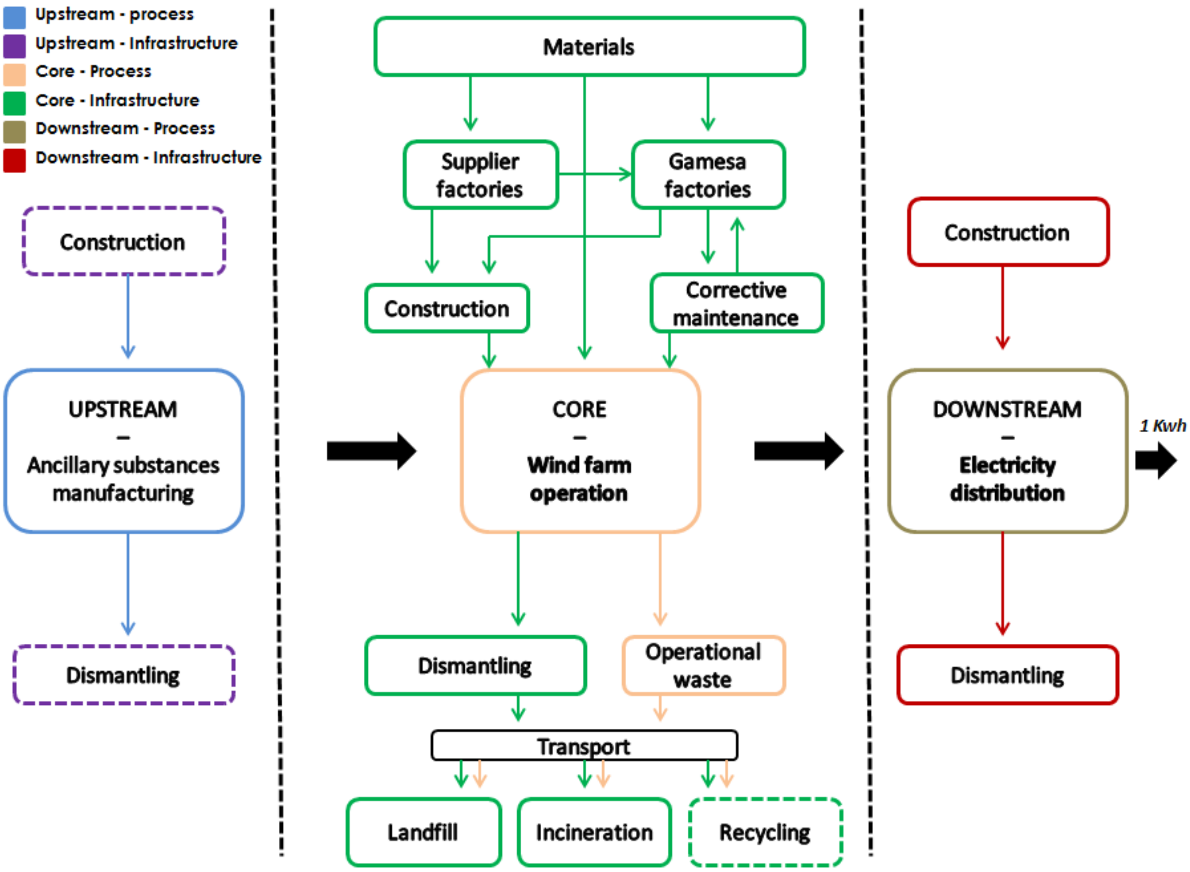


Figure 5.-System boundaries

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 associated 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 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 99,89% of the total material flows of the system had been successfully included (99,51% 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 G114-2.0MW 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 G114 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 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 is 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 year 2012. These data are based on the technology currently used by GCT, and are considered representative as long as the same manufacturing technologies are used. The Spanish electricity mix of the corresponding year has been used to model the power consumption of these production centers, using data from Red Eléctrica Española as source.

In the case of an on-shore G114 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 PLANT	LOCATION	ACTIVITY
Gamesa Ágreda	Ágreda (Soria – Spain)	Nacelle and rotor assembly
Gamesa Cantarey	Reinosa (Cantabria – Spain)	Generator manufacture
Fiberblade As Somozas	As Somozas (A Coruña – 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)	Metal casting
Valencia Power Converters	Benissanó (Valencia – Spain)	Production and assembly of cabinets and converters
TADARSA Avilés[1]	Avilés (Asturias – Spain)	Tower manufacturing

Table 3.- Manufacturing plants

The "TADARSA Avilés" 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 "Grupo Daniel Alonso".

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

COMPONENT	SUPPLIER
Cabinet envelopes	HERCOR
Rear frame	WEC
Nacelle cover / Rotor cover	IMPRE
Low speed shaft	VITKOVICE
Low speed coupling	TOLLOK
High speed coupling	KTR
Crane system	VICINAY
Transformer	ABB
Yaw bearing	REDUCEL
Hydraulic group and pitch system	HINE
Blade bearings	ROLLIX
Paint	HEMPEL / BASF
Oil	SHELL
Resins	MOMENTIVE
Glass Fiber	SAERTEX / OCV

Table 4.- Main suppliers

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 G114 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.

[1] Plant owned by the enterprise "Grupo Daniel Alonso".

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 G114 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.

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
- Decommissioning, restoration and landscaping project of the Sierra de Porta wind farm. Source: TAXUS
- Analysis of end of life options for wind turbine blades. Source: GAIKER

After the 20 years of operation, the land is restored to its previous condition, before the initial construction of the wind farm took place. In order to achieve this land restoration, reached the decommissioning moment Gamesa follows the following steps:

1. Removal of the structure of the wind turbine
2. Demolition of foundation and underground wire 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

For the LCA the following hypotheses have been assumed. All the metals (either ferrous or not) are sent to recycling processes. All the electronic components are correctly managed and sent to a WEEE treatment process. The 26,3% of the plastics are recovered to be sent to recycling processes while the other 73,7% are sent to landfill and incineration processes (Source: Plastics Europe). The building materials used for the foundation of the WTGs are left in the wind farm and the blades are sent to landfill. All the lubricants and hydraulic oils used along the 20 years of operation of the wind farm are properly managed in order to allow subsequent reuses or energetic valorization.

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, including the maintenance staff trips 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 G114 - 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 treatment.

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 behavior 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 preventive maintenance were obtained from the lubrication charts and from the maintenance manual of the G114 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 construction and decommissioning of the electrical grid, which is considered within the sub-module “downstream infrastructure”. The second impact 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.

Due to the difficulties of GCT to separate the energy delivered to each type of consumer at European level, the average value of 6.6% has been considered for the electrical losses in the downstream module. This means that the 6.6% of every generated Kwh, is lost in the transmission and distribution network. In any case, these electrical losses are also forecasted to remain almost constant in Europe until 2020. The source for this value has been Eurelectric, which is the sector association of the electrical industry and has annual statistical studies on the present and future of the electrical market.

With regard to the electrical transmission and distribution system infrastructure, the existing infrastructure on the four European countries that were found more representative of the Gamesa situation was 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 networks 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 G114-2.0 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 functional unit, to which all outcomes are referred to is:

"1 Kwh of electricity generated through an on-shore wind farm of Gamesa G114 - 2.0 MW wind turbine generators, located on a European scenario and operating under medium wind conditions (IEC IIA) and thereafter distributed to a European power transmission grid."

Results are separately shown for the two different core infrastructure scenarios covered within this declaration, depending on the type of tower used.

3.3.1 Scenario A: IEC II Wind class – European Wind Farm - 80m Tower

ECOPROFILE	UNIT	Scenario A: IEC II Wind Class - European Wind Farm - 80 m Tower						
USE OF RESOURCES		1 KWh electricity generated and distributed						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Non-renewable material resources								
Gravel	g	3,842E-03	1,016E-02	2,711E+01	2,712E+01	1,790E+00	9,534E-01	2,986E+01
Iron	g	3,956E-04	7,517E-04	1,098E+00	1,099E+00	7,253E-02	3,934E-01	1,565E+00
Calcite	g	4,985E-04	7,346E-04	1,057E+00	1,058E+00	6,984E-02	2,893E-01	1,417E+00
Clay	g	5,017E-04	2,047E-04	4,516E-01	4,523E-01	2,985E-02	1,491E-01	6,312E-01
Sodium chloride	g	3,873E-05	4,313E-04	2,224E-01	2,229E-01	1,471E-02	8,845E-02	3,261E-01
Nickel	g	2,337E-05	1,238E-05	1,683E-01	1,683E-01	1,111E-02	9,033E-03	1,885E-01
Manganese	g	1,083E-06	1,276E-06	1,272E-02	1,272E-02	8,398E-04	7,655E-05	1,364E-02
Aluminium	g	1,335E-05	3,027E-05	3,827E-02	3,831E-02	2,529E-03	1,985E-02	6,069E-02
Fluorine	g	1,736E-07	4,150E-08	1,609E-05	1,630E-05	1,076E-06	4,400E-05	6,137E-05
Fluorspar	g	3,543E-06	8,885E-07	1,064E-03	1,068E-03	7,051E-05	9,604E-04	2,099E-03
Chromium	g	8,947E-06	4,990E-06	7,060E-02	7,061E-02	4,661E-03	3,575E-03	7,885E-02
Copper	g	1,275E-05	7,015E-06	1,238E-02	1,240E-02	8,186E-04	1,682E-01	1,814E-01
Titanium dioxide	g	2,185E-06	4,102E-06	5,548E-03	5,555E-03	3,666E-04	4,727E-04	6,394E-03
Zinc	g	4,433E-06	6,766E-06	1,639E-03	1,650E-03	1,089E-04	3,277E-04	2,087E-03
Other non-renewable resources[2]	g	1,844E-04	4,985E-05	1,212E-01	1,214E-01	8,012E-03	1,452E-02	1,439E-01
Renewable material resources								
Wood	g	1,870E-04	7,350E-05	5,342E-02	5,368E-02	3,543E-03	1,763E-01	2,335E-01
Water use								
Freshwater	m3	9,640E-08	1,506E-07	2,468E-05	2,492E-05	1,645E-06	1,521E-05	4,178E-05
Saltwater	m3	4,477E-08	1,090E-08	2,297E-06	2,353E-06	1,553E-07	5,245E-07	3,033E-06
Water, unspecified	m3	4,635E-07	2,085E-07	1,706E-04	1,713E-04	1,131E-05	6,065E-05	2,432E-04
Non-renewable energy resources								
Nuclear	MJ	5,896E-05	5,892E-05	1,505E-02	1,517E-02	1,001E-03	3,912E-03	2,008E-02
Crude oil	MJ	1,526E-03	3,423E-04	3,285E-02	3,472E-02	2,291E-03	8,357E-03	4,537E-02
Lignite	MJ	2,552E-05	9,821E-06	4,430E-03	4,465E-03	2,947E-04	1,251E-03	6,011E-03
Hard coal	MJ	3,377E-05	2,323E-05	2,815E-02	2,820E-02	1,861E-03	8,219E-03	3,828E-02
Natural gas	MJ	1,384E-04	4,568E-05	2,896E-02	2,915E-02	1,924E-03	5,054E-03	3,612E-02
Renewable energy resources								
Energy from hydro power	MJ	7,607E-06	1,073E-05	5,432E-03	5,450E-03	3,597E-04	1,871E-03	7,681E-03
Energy from biomass	MJ	3,125E-06	1,335E-06	8,285E-04	8,329E-04	5,497E-05	2,729E-03	3,617E-03
Wind electricity	MJ	1,055E-06	3,970E-07	6,864E-04	6,879E-04	4,540E-05	4,297E-05	7,763E-04
Solar electricity	MJ	1,533E-08	1,125E-08	5,940E-04	5,940E-04	3,920E-05	6,380E-07	6,338E-04
Electricity use in the wind farm[3]	Kwh		4,570E-02		4,570E-02	3,016E-03		4,872E-02
Recycled material resources								
Aluminium	g			9,227E-03	9,227E-03	6,090E-04		9,836E-03
Copper	g			4,675E-03	4,675E-03	3,085E-04		4,983E-03
Steel	g			6,163E-01	6,163E-01	4,068E-02		6,570E-01

[2] Sum of 72 substances

[3] 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.

ECOPROFILE POLLUTANT EMISSIONS	UNIT	Scenario A: IEC II Wind Class - European Wind Farm - 80 m Tower 1 KWh electricity generated and distributed						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Potential environmental impacts								
Acidifying gases	g SO_2 eq	2,138E-04	9,936E-05	3,313E-02	3,344E-02	2,207E-03	3,874E-02	7,439E-02
Eutrophying substances	g PO_4 eq	4,667E-05	4,599E-05	1,576E-02	1,586E-02	1,047E-03	4,186E-02	5,876E-02
Global warming potential (100yrs)	g CO_2 eq	2,500E-02	9,103E-02	6,852E+00	6,968E+00	4,599E-01	1,846E+00	9,274E+00
Ozone depleting potential (20yrs)	g CFC-11 eq	1,320E-08	3,640E-09	5,862E-07	6,030E-07	3,980E-08	9,056E-08	7,334E-07
Formation of ground level ozone	g C_2H_4 eq	1,172E-05	4,523E-06	2,191E-03	2,207E-03	1,457E-04	1,787E-03	4,139E-03
Emissions to air contributing most to the environmental impact categories								
Carbon dioxide, fossil	g	2,305E-02	8,979E-02	6,213E+00	6,326E+00	4,175E-01	1,670E+00	8,413E+00
Methane, fossil	g	7,326E-05	3,592E-05	1,752E-02	1,763E-02	1,164E-03	3,484E-03	2,228E-02
Methane, biogenic	g	3,496E-07	2,210E-07	2,420E-03	2,421E-03	1,598E-04	2,004E-05	2,601E-03
Dinitrogen monoxide	g	5,101E-07	9,296E-07	2,298E-04	2,312E-04	1,526E-05	7,290E-05	3,194E-04
Carbon monoxide, fossil	g	2,906E-05	4,714E-05	3,773E-02	3,781E-02	2,495E-03	1,411E-02	5,441E-02
Methane, chlorodifluoro-, HCFC-22	g	4,566E-10	1,209E-10	6,615E-07	6,621E-07	4,370E-08	1,425E-08	7,201E-07
Methane, bromotrifluoro-, Halon 1301	g	1,150E-09	3,155E-10	2,477E-08	2,623E-08	1,731E-09	5,043E-09	3,301E-08
Methane, bromochlorodifluoro-, Halon 1211	g	1,147E-10	2,972E-11	2,221E-08	2,235E-08	1,475E-09	3,485E-09	2,731E-08
Methane, tetrachloro-, CFC-10	g	2,319E-11	3,555E-11	2,738E-08	2,744E-08	1,811E-09	3,476E-09	3,273E-08
Sulfur dioxide	g	1,477E-04	3,842E-05	1,847E-02	1,865E-02	1,231E-03	2,790E-02	4,778E-02
Nitrogen oxides	g	6,988E-05	1,019E-04	1,958E-02	1,976E-02	1,304E-03	7,725E-03	2,879E-02
Ammonia	g	4,932E-07	1,074E-06	3,215E-04	3,230E-04	2,132E-05	7,891E-04	1,133E-03
Hydrogen chloride	g	6,240E-07	2,982E-07	4,354E-04	4,364E-04	2,880E-05	8,122E-05	5,464E-04
Ethane	g	1,042E-06	2,455E-07	1,038E-04	1,051E-04	6,936E-06	1,937E-05	1,314E-04
Ethene	g	1,007E-07	3,908E-08	3,717E-05	3,731E-05	2,463E-06	1,725E-05	5,702E-05
Pentane	g	2,502E-06	5,684E-07	7,007E-05	7,314E-05	4,827E-06	1,452E-05	9,248E-05
Butane	g	2,021E-06	4,518E-07	5,008E-05	5,255E-05	3,468E-06	1,044E-05	6,645E-05
Propane	g	2,098E-06	4,715E-07	6,878E-05	7,135E-05	4,709E-06	1,426E-05	9,032E-05
Propene	g	9,213E-08	2,281E-08	1,292E-05	1,304E-05	8,606E-07	2,557E-06	1,646E-05
Methane, tetrafluoro-, CFC-14	g	2,688E-09	6,484E-09	6,811E-06	6,820E-06	4,501E-07	4,231E-06	1,150E-05
Emissions to water contributing most to the environmental impact categories								
Phosphate	g	2,603E-05	2,412E-05	1,070E-02	1,075E-02	7,096E-04	4,009E-02	5,155E-02
COD, Chemical Oxygen Demand	g	4,704E-04	3,533E-04	7,935E-02	8,017E-02	5,291E-03	7,282E-03	9,274E-02
Nitrate	g	7,142E-06	3,391E-06	3,183E-03	3,193E-03	2,108E-04	3,143E-03	6,547E-03
Ammonium, ion	g	1,835E-07	7,040E-08	8,603E-04	8,605E-04	5,679E-05	1,678E-05	9,341E-04
Emissions of radioactive isotopes								
C-14	KBq	1,883E-07	1,967E-07	4,236E-05	4,275E-05	2,821E-06	9,292E-06	5,486E-05
Rn-222	KBq	3,416E-03	3,369E-03	7,727E-01	7,795E-01	5,145E-02	1,698E-01	1,001E+00
Kr-85	KBq	7,454E-08	3,217E-08	1,174E-05	1,184E-05	7,816E-07	3,047E-06	1,567E-05
Emissions of biogenic carbon dioxide								
Carbon dioxide, biogenic	g	3,008E-04	1,308E-04	2,089E-01	2,093E-01	1,381E-02	2,299E-01	4,531E-01

ECOPROFILE POLLUTANT EMISSIONS	UNIT	Scenario A: IEC II Wind Class - European Wind Farm - 80 m Tower 1 KWh electricity generated and distributed						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Emissions of toxic substances								
Particulates, <2,5 um to air	g	7,158E-06	9,710E-06	5,061E-03	5,077E-03	3,351E-04	3,040E-03	8,452E-03
Particulates, >10 um to air	g	8,265E-06	7,779E-06	8,379E-03	8,395E-03	5,541E-04	2,709E-03	1,166E-02
Particulates, >2,5 um, and <10 um to air	g	2,942E-06	4,647E-06	6,321E-03	6,328E-03	4,177E-04	3,469E-03	1,021E-02
PAH, polycyclic aromatic hydrocarbons to air	g	2,969E-09	3,407E-09	3,634E-06	3,641E-06	2,403E-07	1,731E-06	5,612E-06
PAH, polycyclic aromatic hydrocarbons to water	g	1,242E-08	2,329E-09	7,801E-07	7,948E-07	5,246E-08	5,440E-08	9,017E-07
Arsenic to air	g	4,784E-09	2,655E-09	8,454E-06	8,461E-06	5,584E-07	4,204E-05	5,106E-05
Cadmium to air	g	2,457E-09	9,981E-10	2,378E-06	2,382E-06	1,572E-07	1,437E-05	1,691E-05
Dioxins to air	g	5,390E-15	7,436E-14	1,274E-11	1,282E-11	8,462E-13	7,587E-12	2,125E-11
Emissions of oil to water and ground								
Oils, unspecified to water	g	1,441E-04	2,085E-05	1,910E-03	2,075E-03	1,369E-04	5,433E-04	2,755E-03
Oils, unspecified to soil	g	1,521E-04	2,103E-05	1,855E-03	2,028E-03	1,338E-04	5,569E-04	2,719E-03

ECOPROFILE WASTE & MATERIAL SUBJECT TO RECYCLING	UNIT	Scenario A: IEC II Wind Class - European Wind Farm - 80 m Tower 1 KWh electricity generated and distributed						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Hazardous waste - Non-radioactive								
Hazardous waste - To incineration	g		2,209E-02	4,492E-05	2,214E-02	1,461E-03	3,054E-02	5,414E-02
Hazardous waste - Radioactive								
Volume for deposit of low-active radioactive waste	m3	2,168E-13	2,134E-13	4,873E-11	4,916E-11	3,245E-12	1,073E-11	6,314E-11
Volume for deposit of radioactive waste	m3	5,464E-14	4,829E-14	1,212E-11	1,222E-11	8,064E-13	2,697E-12	1,572E-11
Other waste								
Non-hazardous waste - To landfill	g			5,666E+00	5,666E+00	3,740E-01	4,368E-01	6,477E+00
Non-hazardous waste - To incineration	g			2,412E-04	2,412E-04	1,592E-05	2,173E-01	2,176E-01
Non-hazardous waste - To recycling	g			1,389E+00	1,389E+00	9,167E-02	6,089E-01	2,090E+00

3.3.2 Scenario B: IEC II Wind class – European Wind Farm - 93m Tower

ECOPROFILE	UNIT	Scenario B: IEC II Wind Class - European Wind Farm - 93 m Tower						
USE OF RESOURCES		1 KWh electricity generated and distributed						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Non-renewable material resources								
Gravel	g	3,842E-03	1,016E-02	2,783E+01	2,785E+01	1,838E+00	9,534E-01	3,064E+01
Iron	g	3,956E-04	7,517E-04	1,383E+00	1,384E+00	9,135E-02	3,934E-01	1,869E+00
Calcite	g	4,985E-04	7,346E-04	1,203E+00	1,205E+00	7,950E-02	2,893E-01	1,573E+00
Clay	g	5,017E-04	2,047E-04	4,786E-01	4,793E-01	3,163E-02	1,491E-01	6,600E-01
Sodium chloride	g	3,873E-05	4,313E-04	2,240E-01	2,244E-01	1,481E-02	8,845E-02	3,277E-01
Nickel	g	2,337E-05	1,238E-05	1,844E-01	1,844E-01	1,217E-02	9,033E-03	2,056E-01
Manganese	g	1,083E-06	1,276E-06	1,705E-02	1,705E-02	1,125E-03	7,655E-05	1,825E-02
Aluminium	g	1,335E-05	3,027E-05	3,884E-02	3,889E-02	2,567E-03	1,985E-02	6,130E-02
Fluorine	g	1,736E-07	4,150E-08	1,809E-05	1,831E-05	1,208E-06	4,400E-05	6,351E-05
Fluorspar	g	3,543E-06	8,885E-07	1,075E-03	1,079E-03	7,121E-05	9,604E-04	2,111E-03
Chromium	g	8,947E-06	4,990E-06	7,670E-02	7,671E-02	5,063E-03	3,575E-03	8,535E-02
Copper	g	1,275E-05	7,015E-06	1,251E-02	1,253E-02	8,269E-04	1,682E-01	1,816E-01
Titanium dioxide	g	2,185E-06	4,102E-06	6,131E-03	6,137E-03	4,051E-04	4,727E-04	7,015E-03
Zinc	g	4,433E-06	6,766E-06	1,673E-03	1,684E-03	1,112E-04	3,277E-04	2,123E-03
Other non-renewable resources[4]	g	1,844E-04	4,985E-05	1,269E-01	1,271E-01	8,391E-03	1,452E-02	1,501E-01
Renewable material resources								
Wood	g	1,870E-04	7,350E-05	5,784E-02	5,810E-02	3,835E-03	1,763E-01	2,382E-01
Water use								
Freshwater	m3	9,640E-08	1,506E-07	2,677E-05	2,702E-05	1,783E-06	1,521E-05	4,401E-05
Saltwater	m3	4,477E-08	1,090E-08	2,524E-06	2,579E-06	1,702E-07	5,245E-07	3,274E-06
Water, unspecified	m3	4,635E-07	2,085E-07	1,822E-04	1,829E-04	1,207E-05	6,065E-05	2,556E-04
Non-renewable energy resources								
Nuclear	MJ	5,896E-05	5,892E-05	1,642E-02	1,654E-02	1,092E-03	3,912E-03	2,154E-02
Crude oil	MJ	1,526E-03	3,423E-04	3,478E-02	3,664E-02	2,419E-03	8,357E-03	4,742E-02
Lignite	MJ	2,552E-05	9,821E-06	4,960E-03	4,995E-03	3,297E-04	1,251E-03	6,576E-03
Hard coal	MJ	3,377E-05	2,323E-05	3,326E-02	3,332E-02	2,199E-03	8,219E-03	4,373E-02
Natural gas	MJ	1,384E-04	4,568E-05	3,116E-02	3,134E-02	2,069E-03	5,054E-03	3,847E-02
Renewable energy resources								
Energy from hydro power	MJ	7,607E-06	1,073E-05	5,875E-03	5,893E-03	3,889E-04	1,871E-03	8,153E-03
Energy from biomass	MJ	3,125E-06	1,335E-06	9,143E-04	9,188E-04	6,064E-05	2,729E-03	3,709E-03
Wind electricity	MJ	1,055E-06	3,970E-07	7,240E-04	7,255E-04	4,788E-05	4,297E-05	8,163E-04
Solar electricity	MJ	1,533E-08	1,125E-08	6,120E-04	6,120E-04	4,039E-05	6,380E-07	6,530E-04
Electricity use in the wind farm[5]	Kwh		4,570E-02		4,570E-02	3,016E-03		4,872E-02
Recycled material resources								
Aluminium	g			9,227E-03	9,227E-03	6,090E-04		9,836E-03
Copper	g			4,675E-03	4,675E-03	3,085E-04		4,983E-03
Steel	g			7,694E-01	7,694E-01	5,078E-02		8,202E-01

[4] Sum of 72 substances

[5] 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.

ECOPROFILE	UNIT	Scenario B: IEC II Wind Class - European Wind Farm - 93 m Tower						
POLLUTANT EMISSIONS		1 KWh electricity generated and distributed						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Potential environmental impacts								
Acidifying gases	g SO_2 eq	2,138E-04	9,936E-05	3,603E-02	3,634E-02	2,399E-03	3,874E-02	7,747E-02
Eutrophying substances	g PO_4 eq	4,667E-05	4,599E-05	1,732E-02	1,741E-02	1,149E-03	4,186E-02	6,041E-02
Global warming potential (100yrs)	g CO_2 eq	2,500E-02	9,103E-02	7,583E+00	7,699E+00	5,081E-01	1,846E+00	1,005E+01
Ozone depleting potential (20yrs)	g CFC-11 eq	1,320E-08	3,640E-09	6,299E-07	6,467E-07	4,269E-08	9,056E-08	7,800E-07
Formation of ground level ozone	g C_2H_4 eq	1,172E-05	4,523E-06	2,522E-03	2,538E-03	1,675E-04	1,787E-03	4,492E-03
Emissions to air contributing most to the environmental impact categories								
Carbon dioxide, fossil	g	2,305E-02	8,979E-02	6,881E+00	6,994E+00	4,616E-01	1,670E+00	9,126E+00
Methane, fossil	g	7,326E-05	3,592E-05	1,947E-02	1,958E-02	1,292E-03	3,484E-03	2,435E-02
Methane, biogenic	g	3,496E-07	2,210E-07	2,451E-03	2,452E-03	1,618E-04	2,004E-05	2,634E-03
Dinitrogen monoxide	g	5,101E-07	9,296E-07	2,402E-04	2,417E-04	1,595E-05	7,290E-05	3,305E-04
Carbon monoxide, fossil	g	2,906E-05	4,714E-05	4,603E-02	4,611E-02	3,043E-03	1,411E-02	6,326E-02
Methane, chlorodifluoro-, HCFC-22	g	4,566E-10	1,209E-10	6,719E-07	6,724E-07	4,438E-08	1,425E-08	7,311E-07
Methane, bromotrifluoro-, Halon 1301	g	1,150E-09	3,155E-10	2,644E-08	2,791E-08	1,842E-09	5,043E-09	3,479E-08
Methane, bromochlorodifluoro-, Halon 1211	g	1,147E-10	2,972E-11	2,482E-08	2,497E-08	1,648E-09	3,485E-09	3,010E-08
Methane, tetrachloro-, CFC-10	g	2,319E-11	3,555E-11	2,832E-08	2,838E-08	1,873E-09	3,476E-09	3,373E-08
Sulfur dioxide	g	1,477E-04	3,842E-05	2,008E-02	2,027E-02	1,338E-03	2,790E-02	4,951E-02
Nitrogen oxides	g	6,988E-05	1,019E-04	2,126E-02	2,143E-02	1,414E-03	7,725E-03	3,057E-02
Ammonia	g	4,932E-07	1,074E-06	3,565E-04	3,581E-04	2,363E-05	7,891E-04	1,171E-03
Hydrogen chloride	g	6,240E-07	2,982E-07	4,775E-04	4,784E-04	3,157E-05	8,122E-05	5,912E-04
Ethane	g	1,042E-06	2,455E-07	1,161E-04	1,174E-04	7,747E-06	1,937E-05	1,445E-04
Ethene	g	1,007E-07	3,908E-08	4,354E-05	4,368E-05	2,883E-06	1,725E-05	6,381E-05
Pentane	g	2,502E-06	5,684E-07	7,539E-05	7,846E-05	5,178E-06	1,452E-05	9,815E-05
Butane	g	2,021E-06	4,518E-07	5,407E-05	5,654E-05	3,732E-06	1,044E-05	7,071E-05
Propane	g	2,098E-06	4,715E-07	7,549E-05	7,806E-05	5,152E-06	1,426E-05	9,747E-05
Propene	g	9,213E-08	2,281E-08	1,450E-05	1,461E-05	9,644E-07	2,557E-06	1,813E-05
Methane, tetrafluoro-, CFC-14	g	2,688E-09	6,484E-09	6,853E-06	6,862E-06	4,529E-07	4,231E-06	1,155E-05
Emissions to water contributing most to the environmental impact categories								
Phosphate	g	2,603E-05	2,412E-05	1,194E-02	1,199E-02	7,914E-04	4,009E-02	5,287E-02
COD, Chemical Oxygen Demand	g	4,704E-04	3,533E-04	8,145E-02	8,227E-02	5,430E-03	7,282E-03	9,498E-02
Nitrate	g	7,142E-06	3,391E-06	3,505E-03	3,516E-03	2,320E-04	3,143E-03	6,891E-03
Ammonium, ion	g	1,835E-07	7,040E-08	8,632E-04	8,635E-04	5,699E-05	1,678E-05	9,372E-04
Emissions of radioactive isotopes								
C-14	KBq	1,883E-07	1,967E-07	4,674E-05	4,713E-05	3,111E-06	9,292E-06	5,953E-05
Rn-222	KBq	3,416E-03	3,369E-03	8,521E-01	8,589E-01	5,668E-02	1,698E-01	1,085E+00
Kr-85	KBq	7,454E-08	3,217E-08	1,331E-05	1,341E-05	8,853E-07	3,047E-06	1,735E-05
Emissions of biogenic carbon dioxide								
Carbon dioxide, biogenic	g	3,008E-04	1,308E-04	2,185E-01	2,189E-01	1,445E-02	2,299E-01	4,633E-01

ECOPROFILE POLLUTANT EMISSIONS	UNIT	Scenario B: IEC II Wind Class - European Wind Farm - 93 m Tower 1 KWh electricity generated and distributed						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Emissions of toxic substances								
Particulates, <2,5 um to air	g	7,158E-06	9,710E-06	5,631E-03	5,648E-03	3,728E-04	3,040E-03	9,061E-03
Particulates, >10 um to air	g	8,265E-06	7,779E-06	9,985E-03	1,000E-02	6,601E-04	2,709E-03	1,337E-02
Particulates, >2,5 um, and <10 um to air	g	2,942E-06	4,647E-06	7,371E-03	7,378E-03	4,870E-04	3,469E-03	1,133E-02
PAH, polycyclic aromatic hydrocarbons to air	g	2,969E-09	3,407E-09	3,867E-06	3,873E-06	2,556E-07	1,731E-06	5,860E-06
PAH, polycyclic aromatic hydrocarbons to water	g	1,242E-08	2,329E-09	9,923E-07	1,007E-06	6,647E-08	5,440E-08	1,128E-06
Arsenic to air	g	4,784E-09	2,655E-09	8,651E-06	8,658E-06	5,715E-07	4,204E-05	5,127E-05
Cadmium to air	g	2,457E-09	9,981E-10	2,405E-06	2,408E-06	1,589E-07	1,437E-05	1,694E-05
Dioxins to air	g	5,390E-15	7,436E-14	1,525E-11	1,533E-11	1,012E-12	7,587E-12	2,393E-11
Emissions of oil to water and ground								
Oils, unspecified to water	g	1,441E-04	2,085E-05	2,054E-03	2,219E-03	1,464E-04	5,433E-04	2,908E-03
Oils, unspecified to soil	g	1,521E-04	2,103E-05	1,987E-03	2,160E-03	1,426E-04	5,569E-04	2,860E-03

ECOPROFILE WASTE & MATERIAL SUBJECT TO RECYCLING	UNIT	Scenario B: IEC II Wind Class - European Wind Farm - 93 m Tower 1 KWh electricity generated and distributed						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Hazardous waste - Non-radioactive								
Hazardous waste - To incineration	g		2,209E-02	4,492E-05	2,214E-02	1,461E-03	3,054E-02	5,414E-02
Hazardous waste - Radioactive								
Volume for deposit of low-active radioactive waste	m3	2,168E-13	2,134E-13	5,376E-11	5,419E-11	3,577E-12	1,073E-11	6,850E-11
Volume for deposit of radioactive waste	m3	5,464E-14	4,829E-14	1,337E-11	1,347E-11	8,892E-13	2,697E-12	1,706E-11
Other waste								
Non-hazardous waste - To landfill	g			6,349E+00	6,349E+00	4,190E-01	4,368E-01	7,205E+00
Non-hazardous waste - To incineration	g			2,412E-04	2,412E-04	1,592E-05	2,173E-01	2,176E-01
Non-hazardous waste - To recycling	g			1,706E+00	1,706E+00	1,126E-01	6,089E-01	2,428E+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.

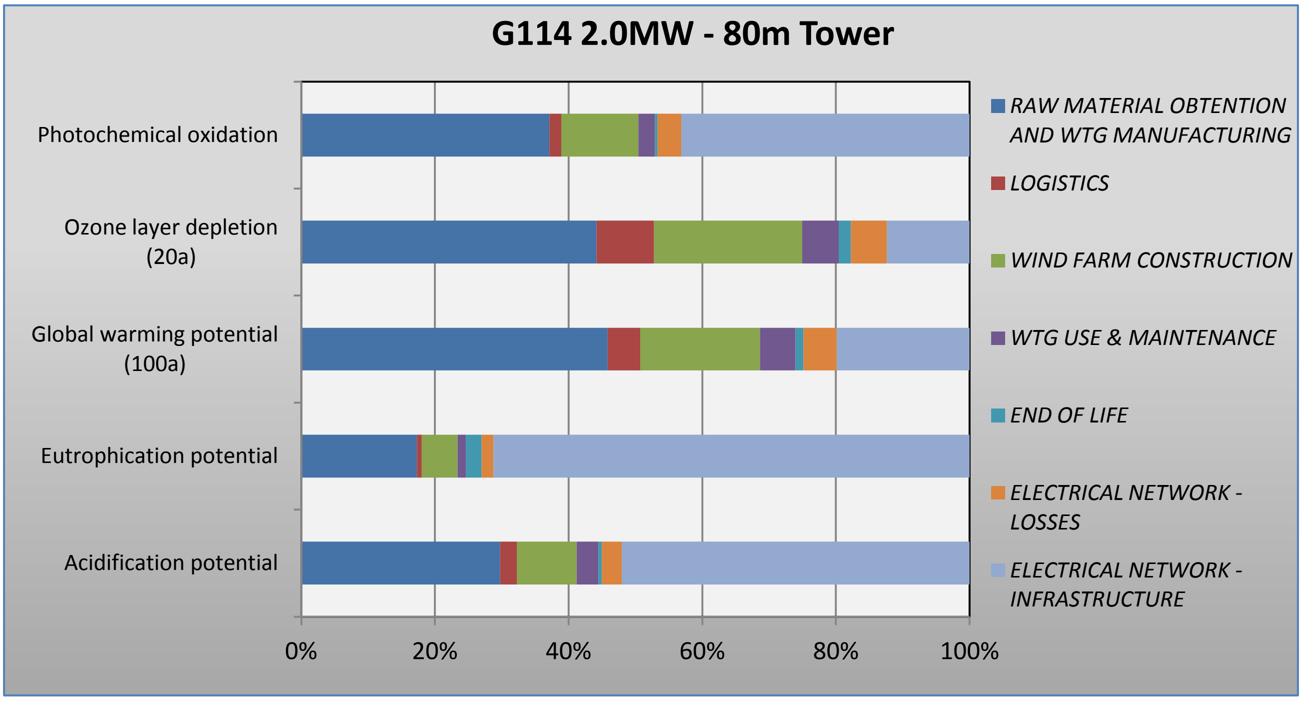


Figure 6.-Environmental hot spots

As shown in the figures above, there are two main phases within the life cycle responsible of approximately the 75% of all the environmental impacts in average.

These are raw material obtention and WTG manufacturing, and electrical network infrastructure. For example, in the 80m tower case, the raw material obtention and WTG manufacturing goes from a 17,31% of the life cycle impacts in the category "Eutrophication potential" to a maximum of 45,86% in the category "Global Warming Potential". In the other hand, the phase "Electrical network infrastructure" goes from a 12,35% in the category "Ozone layer depletion" to a 71,23% in "Eutrophication potential". The figure has the same shape for the 93m tower scenario.

For these reasons these stages are the most relevant phases within the life cycle of the energy generated by a G114 2.0 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 35% (in average for the 5 impact categories) of the environmental impacts of the energy generated and distributed by a G114 2.0 MW WTG is caused in the raw material obtention and 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 steel parts of the WTG and the subsequent machining phases. The most critical components in this phase are the blades, the low speed shaft and the tower.

In regard to the electricity grid infrastructure, it accounts to nearly the 40% of the environmental impacts in average. The impacts are mostly related to the raw materials used for the high voltage wires (copper, aluminum, steel and polymers), as well as for the transport associated to bring these materials to the European countries where the wires are manufactured.

In relation to the wind farm construction, it represents the 13% of the impacts (In average). The most relevant environmental aspects for the construction are the materials which compose the foundation (mainly concrete and steel), followed by the fuel burned in the construction machinery.

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 G114 2.0 MW Wind turbines.

More detailed conclusions about the environmental impacts were made in the full LCA report. Please, refer to Gamesa Corporación Tecnológica for further information.

4. ADDITIONAL ENVIRONMENTAL IMPACT

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.

Source: Gamesa Sustainability report 2013 (Spain inventory), http://www.gamesacorp.com

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 5.- Most significant impacts on biodiversity in 2013 (by type of impact)

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 behavior. 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 6.- 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 7.- Biodiversity studies

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 2.0MW Gamesa wind farms in Europe, which is 30 MW of installed capacity.

4.2.1 Description of land use

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

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 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 m2. Predominantly agricultural activities occupy most of the surrounding land.

4.2.1.3 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."

4.2.1.4 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 mm2 sections.

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.

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. 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

Below it is represented the land use of the mentioned wind farms prior to their installation.

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**
Wetlands	0	0	0	**0**
Water	0	0	0	**0**
TOTAL	**178.514**	**64.000**	**151.400**	**393.914**

Table 8.- Previous land use

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	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**
Wetlands	0	0	0	**0**
Water	0	0	0	**0**
TOTAL	**178.514**	**64.000**	**151.400**	**393.914**

Table 9.- Land use after erection

4.2.3 Number of years of occupation

Wind Farm	Start of the activity	Number of years until 2014
Los Lirios	2010	4
Alto de la degollada	2010	4
Barchín del Hoyo	2011	3

Table 10.- 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 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 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 quantized 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	CO2 and others	Waste	<10-5	<10-4	0
Concrete spills	Affection to flora	-	Concrete	<10-5	<10-4	0

Table 11.- Environmental risks

In conclusion, it is seen that 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 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 environment and for the general public a limit of 100 µT a 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 G114, the only relevant noise is the aerodynamic one.

The G114 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, five low noise operation modes are available for G114 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.
- G114 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 Gorka Benito Alonso, 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 for an Environmental Product Declaration, EPD, published by the International EPD Consortium and PCR version 2.02 2007:08 CPC 171 & 173: Electricity, Steam, and Hot and Cold Water Generation and Distribution. The verifier Gorka Benito Alonso has been accredited by the International EPD® System to certify Environmental Product Declarations, EPD. This certification is valid until the date 14-10-2017.

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 Vasagatan 15-17 SE-111 20 Stockholm Sweden l **info@environdec.com**	
INDEPENDENT VERIFICATION OF THE DECLARATION AND DATA, ACORDING TO ISO 14025:2006	
□ **Internal** ✓**External** □ **Certification process**	Gorka Benito Alonso IK Ingeniería S.L. g.benito@ik-ingenieria.com
PRODUCT CATEGORY RULES	
PCR 2007:08, Version 2.02, CPC 171 & 173: Electricity, Steam, and Hot and Cold Water Generation and Distribution, Date 2013-07-17	
PCR REVIEW	
Product Category Rules (PCR) review was conducted by: The Technical Committee of the International EPD® System. o Chair: Massimo Marino. Contact via info@environdec.com. o PCR Moderator: Caroline Setterwall, ABB.	
VALID UNTIL	REGISTER NUMBER
14 October 2017	**S-P-00540**
GAMESA CORPORACIÓN TECNOLÓGICA	
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.Gamesacorp.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 Corporación Tecnológica:

www.gamesacorp.com

Additional information about previous LCA and EPD reports made by Gamesa:

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

- Introduction, usage and key elements of the programme: http://www.environdec.com/documents/pdf/EPD_introduction_080229.pdf
- General instructions of the programme: http://www.environdec.com/documents/pdf/EPD_instructions_080229.pdf
- Annexes: http://www.environdec.com/documents/pdf/EPD_annexes_080229.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 2.2 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
- 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 Turbine generator system