ENVIRONMENTAL PRODUCT DECLARATION

SIEMENS Gamesa
RENEWABLE ENERGY

Electricity from:

European G126-2.625 MW On-shore Wind Farm

Version:	1.0
Date:	2017-06-21
Valid until:	2020-06-21
Reg. number:	S-P-01048
Geographical validity:	European

EPD®

UN CPC 171 – Electricity, steam, and hot/cold water generation & distribution
PCR 2007:08 Version 3.0

CONTENT

ACRONYMS AND ABBREVIATIONS

AEP	Annual Energy Production
B2B	Business to Business
CoE	Cost of Energy
EPD	Environmental Product Declaration
EIA	Environmental Impact Assessment
GPI	General Programme Instructions
PCR	Product Category Rules
CPC	Central Product Classification
IEC	International Electro technical Commission
ISO	International Organization for Standardization
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 UNIT

This document represents the certified Environmental Product Declaration (EPD), of the electricity generated through an on-shore wind farm of Siemens-Gamesa G126 - 2.625 MW wind turbine generators, located in a European scenario and operating under low wind conditions (IEC III-a wind class).

Siemens-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 unit, to which all outcomes are referred to is:

"1 Kwh of electricity generated through an on-shore wind farm of Siemens-Gamesa G126 - 2.625 MW wind turbine generators, located in a European scenario and operating under low wind conditions (IEC III-a), and thereafter distributed to a 132 KV European electrical grid"

A total reference flow of 2,005,452.108 MWh has been used to refer all the inputs and outputs of the system to 1 single KWh. This reference flow represents the whole net electricity generation expected for 9 G126-2.625 MW WTG under low wind conditions during its service life, which has been set to 20 years.

Siemens-Gamesa is able to supply different kind of towers, seeking a right placement of the rotor at the height that optimizes the energy harvested. For the baseline scenario, 84 meters high towers have been considered.

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 is 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 3.0 CPC 171 & 173: Electricity, Steam, and Hot and Cold Water Generation and Distribution.
- General Programme Instructions for Environmental Product Declarations, Ver. 2.5.
- 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

2. THE COMPANY AND THE PRODUCT

2.1 SIEMENS-GAMESA RENEWABLE ENERGY

Together, Siemens Wind Power and Gamesa have created a leader in the renewable energy industry, to provide cleaner, more reliable and more affordable energy to society, and to create lasting value for all their stakeholders.

Siemens Wind Power and Gamesa have a proven track record of excellence in operation and maintenance. Together, the company benefits from an increased scale and global reach. We offer adaptive service portfolios that are tailored to our customers' diverse operating models, advanced diagnostics and digitalization capabilities, as well as customized offshore offerings.

SIEMENS Gamesa
RENEWABLE ENERGY

ON-SHORE BUSINESS

Our competitive wind turbine technologies cover all wind classes and site conditions. The combined portfolio enables us to fulfill all customer requirements, helping to reduce the cost of energy. United, Siemens Wind Power and Gamesa profit from a leading position in emerging markets, such as China, India and Latin America, and a strong foothold in developed markets like North America or Europe.

OFF-SHORE BUSINESS

The united company leverages Siemens' 25 years of experience and leadership in offshore wind energy. It offers full-scope solutions such as grid-infrastructure and comprehensive service. Our competitive technologies help to minimize risk and optimize return on investment of offshore wind power plants.

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 wind turbine generators
✓ G10X - 4.5 MW
✓ G114 - 2.0 MW
✓ G114 - 2.5 MW
✓ G126 - 2.625 MW
✓ G132 - 3.3 MW
✓ G128 – 5.0 MW
✓ G132 – 5.0 MW

- ISO 14064:2006 - Greenhouse gases
- ISO 9001:2008 - Quality management systems
- OHSAS 18001:2007 - Occupational health and safety management systems

2.2 PRODUCT SYSTEM DESCRIPTION

The baseline system under study is an on-shore G126 2.625 MW European wind farm, using 84-meter towers and operating under low wind conditions (IEC IIIa). Since Siemens-Gamesa started the LCA study, it was found interesting the concept that its results were extrapolated as far as possible to a test case of a European wind farm and not only to a specific site. The reason pursued, 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 wind farm model, representing a Siemens-Gamesa European average client.

2.2.1 The European G126 2.625MW wind site

The differences between the environmental impacts caused by the commissioning 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 product distribution stage. The farther the wind farm is, the more logistics needed.

To determine the geographical location of an average Siemens-Gamesa 2.625 MW wind farm, an analysis has been performed including the location of all the WTGs with a nominal power over 2.0 MW[1] which have been sold by Gamesa during the last 5 years (2012-2016). Starting from that information, 6 different European countries have been selected, covering a 77,19% of the total installed power.

The following table, contains the 6 selected locations including their relative representativeness within the LCA and the number of installed machines in the test site.

EUROPEAN AVERAGE WIND FARM DESCRIPTION					
#	COUNTRY	WIND FARM NAME	AREA	REPRESENTATIVENESS	Nº WTG
1	UK	Kilgallioch	Ayrshire	26,50%	9
2	Spain	Santa Maria de Nieva	Andalusia	25,63%	
3	Italy	Santa Anna	Crotone-Calabria	15,81%	
4	Poland	Parsowek	Western Pomerania	14,08%	
5	France	Herbissones	Champagne-Ardennes	10,38%	
6	Finland	Pori	Pori	7,60%	

Table 1: European average wind farm description

The countries analyzed are UK, Spain, Italy, Poland, France and Finland. These 6 countries are considered representative of the European situation of Siemens-Gamesa 2.625 MW clients. For every of these 6 countries, one specific wind farm has been selected as geographical reference.

Regarding the size of the wind farm, the average size of a wind site in the selected countries has been calculated rounding the number up to 9 wind turbines. Therefore, the installed power considered for the European G126 average wind farm is set to 23,625 MW.

When modelling the infrastructures shared by many wind turbines (i.e. transformer substation, internal wiring, connection infrastructure to the electrical network, road

[1] No G126 wind farms have been installed so far.

conditioning to allow access to machinery…), this average wind park size of 23,625 MW installed has been used as baseline.

2.2.2 The SIEMENS-GAMESA G126-2.625 MW Wind turbine generator

This wind turbine generator is a 2.625 MW rated power turbine, with a three-blade rotor. It has a rotor diameter of 126 m, and a swept area of 12,469 m2. Gamesa harnessed the experience acquired through the installation of 26 GW of its high performance 2.0 MW platform to develop this new model, capable of generating even more power at low-wind sites while remaining as competitive as the existing models with smaller rotor.

SPECIFICATIONS

General Details	G126-2.625 MW
Rated power	2.625 MW
Wind class	IIIA
Rotor diameter	126 m
Swept area	12.469 m²
Power density	210,52 W/m²
Control	Pitch y velocidad variable
Gearbox	3 etapas
Generator	Doblemente alimentado
Frequency	50Hz / 60 Hz
Blades	
Length	62 m
Airfoil	Gamesa
Towers	
Height	84, 102, 129, 137 m y según emplazamiento

Figure 1.- G126 WTG Technical specifications

The company's most recently developed turbines thus emerge through this approach: G114-2.0 MW IIA/IIIA, G114-2.5 MW IIA, and now G126-2.625 MW IIIA.

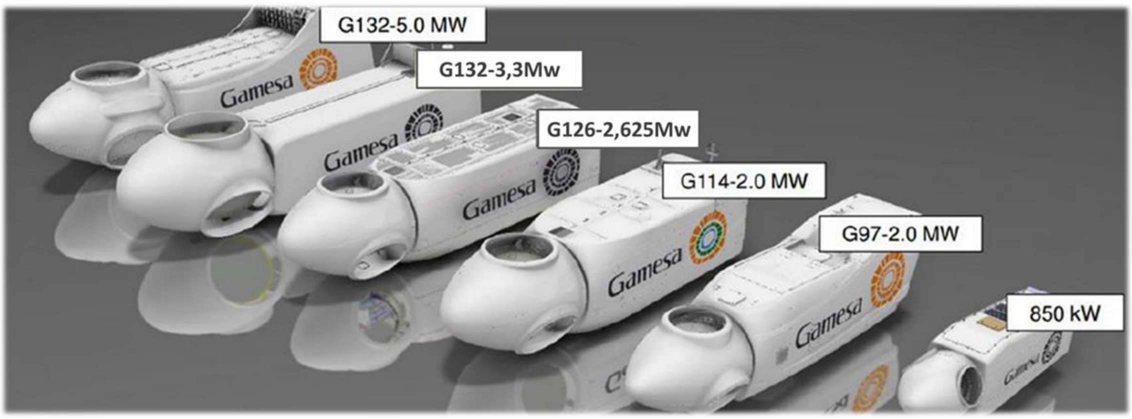

Figure 2.- Gamesa wind turbine generators power range

Following the evolutionary model of the 2.5 platform, and minimizing the risk associated with new technologies, the G126 MW is equipped with a 62 meter blade based on the 56-meter variant already delivering maximum production at lower noise and comprehensively validated for G114 turbines. Based on the same principle, the electrical system incorporated in the G126 is common for all 2.5 MW models.

The picture below shows the G126 2,625 MW power curve compared to the previous G114 WTG.

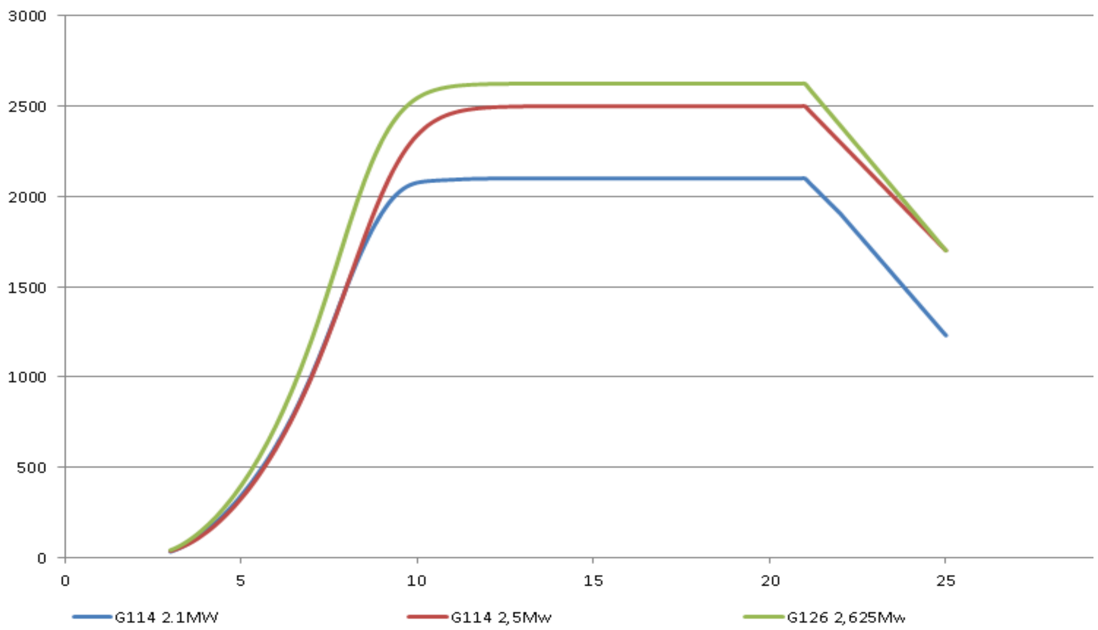

Figure 3.- Siemens-Gamesa 2.0/2.5 MW platform power curves.

Boasting a 20% increase in power production compared to the G114-2.0 MW model, the G126 MW wind turbine rounds off Gamesa's offering for Class III sites. With this new addition, Sieemens-Gamesa completes its 2.5 MW product portfolio, with three different rotors, tower heights from 68 to 137 meters, and environmental options enabling installation at even the most complex sites.

The expected service life of the product is stated in 20 years, not considering Siemens-Gamesa's life extension program which can significantly enhance this period of time. For the present LCA, a life cycle model has been created, using 84-meters high tapered steel towers.

2.2.3 Electricity transmission and distribution infrastructure

Once the wind is converted into electricity by the G126 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 step, 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.

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.

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). At the exit of the wind farm there is another transformer station allowing the delivery of high voltage electricity (132 KV) to the general network.

The distance between the wind farm transformer station and the connection point to the electrical grid is a variable value dependent on the specific location. According to previous Gamesa experiences, this value could be assumed to be 15 km average, which is the length of the line modeled for the LCA.

It should also be noted, that Siemens-Gamesa is not a company dedicated to the energy distribution business. Instead, it is dedicated to the manufacture of wind turbine generators, so that the environmental impacts of this stage are inside the wind energy life cycle, but outside of the direct range of the Siemens-Gamesa activities.

3. ENVIRONMENTAL PERFORMANCE BASED ON LCA

3.1 LIFE CYCLE ASSESSMENT METHODOLOGY

As stated in ISO 14025:2010 (Environmental labels and declarations - Type III environmental declarations - Principles and procedures), the environmental impact data outlined in an Environmental 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 cradle-to-grave life cycle impact of the electricity generated through an on-shore wind farm of G126 - 2.625 MW wind turbine generators, located on a European scenario, operating under low wind conditions (IEC IIIa) and thereafter distributed to a European 132KV power transmission grid.

Obviously, the energy life cycle is a complex system in which it is necessary to clearly establish the boundaries between the different phases to avoid mistakes. Following the recommendations of the PCR, the whole 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.

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 below 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.

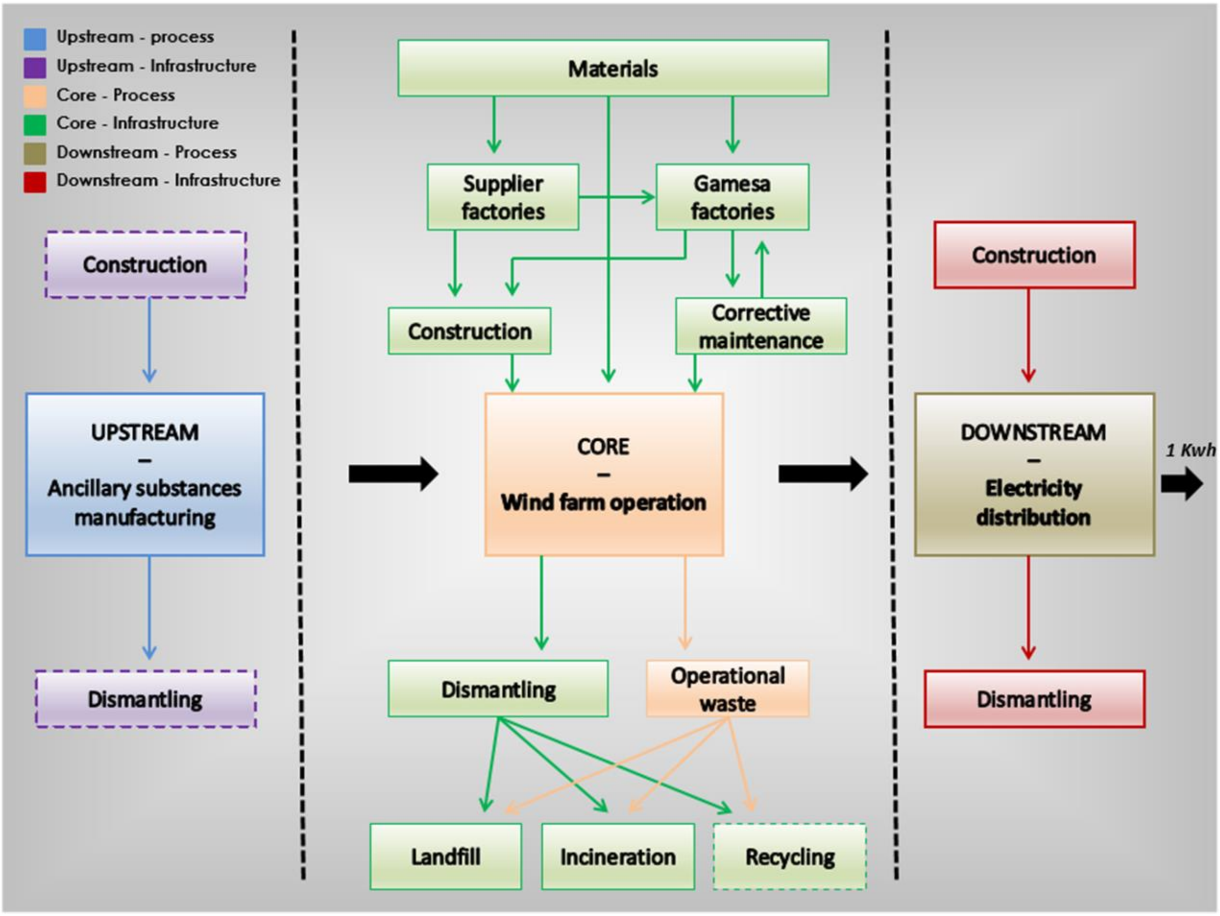

Figure 4.-System boundaries

The data used to create the models of the life cycle phases described in the above diagram, have been obtained directly from Siemens-Gamesa renewables 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 Siemens-Gamesa 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, 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.

By the time the study ended, the 99,81% of the total material flows of the system had been successfully included. In addition, all the energy flows incurred in Siemens-Gamesa manufacturing plants have also been included in the analysis. Regarding data quality, the environmental impact of the processes where other generic data were used, is below 10% of the overall environmental impact from the product system.

From these primary data, when creating the life cycle model of the analyzed system the Ecoinvent 3.2 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 G126-2.625 MW wind farm, reflect the technology currently used by the manufacturer and are considered representative for the period of validity of this EPD.

In the points of the study where impact allocation was required, physical allocation criteria was used to resolve multifunctionality issues, as recommended by the PCR. In the manufacturing stage of the wind turbine, three different manufacturing centers required physical criteria to allocate their global impacts to every produced component, given the fact that they produce components not only for the G126 wind turbine but also for other machines. These centers were Aoiz (blades), Valencia power converters (electrical cabinets) and Ágreda (Nacelle and Hub assembly).

In the next sections, the scope of the study and the data sources used are further detailed for every of the different stages that compose the life cycle of the generated and distributed energy.

3.2.1 Upstream

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 wind power requires no fuel for equipment operation, 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.

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 G126 WTG. 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.

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

3.2.2 Core – Infrastructure

The core infrastructure phase encompasses all the steps related to the construction, 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 WTGs 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 Siemens-Gamesa and its suppliers. Besides, the expected corrective maintenance actions for the machinery during its service life (estimated component replacements and repairs) are included. All the environmental impacts arising from the logistics related to the previously mentioned concepts are part of the core module too.

WIND FARM CONSTRUCTION

The main environmental aspects of the construction of a wind farm are commonly related to the machinery use during the groundwork and WTG assembly, as well as the material consumption for the foundations and terrain adaptation. For this EPD, Siemens-Gamesa has calculated the environmental impact arisen from the construction of a 9 WTG wind farm, as explained in section 2.2.1.

Wind farm construction is not one of the main activities conducted by Siemens-Gamesa, but the manufacturer holds reliable primary data on wind farm construction in a European context from its previous LCA experiences, which have been adapted for the simulation of this virtual European 9 WTG windfarm.

The energy consumption for the WTG assembly and the materials consumed when building the foundations of the WTGs, are primary data directly gathered by Siemens-Gamesa, while other machinery consumption (hydraulic diggers, dumpers,…) and terrain adaptation materials are data from projects built during the period 2015 – 2016. This wind farm model does not represent one single specific site. Instead, it represents the environmental impacts occurred during the construction stage of an average 9 WTG wind farm in a European context.

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.

Figure 5.- Santa María de Nieva wind farm (Spain)

WIND TURBINE GENERATOR MANUFACTURING

On the other hand, Siemens-Gamesa is responsible for the manufacturing of most of the major components of the wind turbine. The company, as manufacturer of the WTGs has provided primary data on the raw materials, energy flows and generated waste streams during the wind turbines manufacturing stage, according to their real manufacturing processes. These data are based on the technology currently used by Siemens-Gamesa, and are considered representative as long as the same manufacturing technologies are used.

Data on the environmental aspects of Siemens-Gamesa production processes have been collected during a full year period (2016). In addition, the material breakdown of the WTGs has been extracted from the BOMs of the different turbine models actually manufactured during the year 2016.

Electricity consumption was identified as a relevant environmental aspect of the manufacturing stage on previous LCA studies conducted by Gamesa. Therefore, the company decided to acquire its electricity from 100% renewable sources instead of using the general electricity mix, in order to minimize this environmental impact. All the electricity consumed in the manufacturing centers and offices owned by Gamesa during 2016, has a 100% renewable Guarantee of Origin certified by the supplier of the electricity, which in this case is Iberdrola.

Figure 6.-Blade manufacturing in Aoiz

In the case of an on-shore G126 2.625 MW 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
Gamesa Aoiz	Aoiz (Navarra – Spain)	Blade manufacture
GET ECHESA Asteasu	Asteasu (Guipuzcoa – Spain)	Gearbox parts machining
GET TRELSA Lerma	Lerma (Burgos – Spain)	Gearbox assembly
WEC	Itziar (Guipuzcoa – Spain)	Metal casting[2]
Valencia Power Converters	Benissanó (Valencia – Spain)	Assembly of electrical cabinets and converters
TADARSA Avilés	Avilés (Asturias – Spain)	Tower manufacturing[3]

Table 2.- Manufacturing plants

[2] The plant WEC belongs to the company Grupo WEC.
[3] The plant TADARSA Avilés belongs to the company Windar Renewables.

These facilities are the ones responsible of the manufacture and assembly of the main components of the WTG G126 2.625 MW, given a European client.

In addition to this processes, which are the ones related to the main components, in the table below other suppliers that have been considered for the LCA are also listed. The manufacturing processes carried out by these suppliers, have been analyzed using manufacturing processes from ecoinvent 3.2 database.

COMPONENT	SUPPLIER
Main shaft	VITKOVICE
Main shaft bearings	KOYO
Blade bearings	ROLLIX
Low speed coupling	TOLLOK
High speed coupling	KTR
Transformer	ABB
Yaw ring	REDUCEL
Hydraulic group	HINE
Nacelle/Rotor cover	INPRE
Hydraulic group	HINE
Crane system	VICINAY

Table 3.- Main suppliers

Data on components directly purchased from suppliers and the distances traveled by these components to Siemens-Gamesa manufacturing plants, closely match the reality of a European average scenario. In addition, data on the distance traveled by the main components of the WTG to the wind farm, have been considered taken into account the European average wind farm location explained in section 2.2.1.

REINVESTMENTS

All the G126 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 G126 2.625 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 Gamesa.

END-OF-LIFE

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

- Siemens-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

For the LCA the following hypotheses have been assumed.

SUB-SYSTEM	END-OF-LIFE HYPOTHESIS
FOUNDATION MATERIALS	- Above ground surface is removed and the rest is left in situ.
TOWER	- Fully recyclable.
BLADES	- 95% Landfilled - 5% Repaired
BLADE BEARINGS	- Fully recyclable.
HUB	- Fully recyclable.
ROTOR COVER	- Landfilled
NACELLE COVER	- Landfilled
BEAM SYSTEM / NACELLE STRUCTURE	- Fully recyclable.
MAIN SHAFT	- Fully recyclable.
HIGH SPEED SHAFT	- Fully reusable / repairable.
GEARBOX	- Fully reusable / repairable.
GENERATOR	- 85% Recycled - 10% Landfilled
TRANSFORMER	- 85% Recycled - 15% Landfilled
PITCH SYSTEM	- Fully reusable / repairable.
HYDRAULIC GROUP	- Fully reusable / repairable.
YAW SYSTEM	- Fully recyclable.
CRANE SYSTEM	- Fully repairable.
ELECTRICAL CABINETS / CONVERTER	- 90% Recycled - 10% Landfilled
WIND FARM WIRING AND WTG CABLES	- 95% Recycled - 5% Landfilled

Table 4.- End-of-life hypotheses

3.2.3 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 the following concepts have been considered:

- Preventive maintenance required during the lifespan of the wind farm, including the maintenance staff trips to the wind farm.
- 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.

Finally, the core also contains a vital part of the wind turbine life cycle, which is the 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. These are also primary data directly provided by the manufacturer.

3.2.4 Downstream

Finally. 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.

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.

Given the fact that the present study does not cover a specific site but an average European location, the electrical losses that occur between the wind farm electrical substation and the main electricity network, can't be directly measured. Siemens-Gamesa has experienced difficulties trying to separate the distributed energy losses to every kind of European customer. Because of that, an average value of 2,2% until a 132 KV network has been used to simulate these electrical losses, according to European Regulators Group for electricity and gas (ERGEG).

This means that 2,2% of every generated Kwh, is lost in the distribution network between the wind farm and the declared customer.

On the other hand, the distance between the wind farm transformer station and the connection point to the electrical grid is a variable value dependent on the specific location. According to previous Gamesa experiences, this value could be assumed to be 15 km average, which is the length of the line modeled for the LCA.

The data used for the modelization of the electrical networks have been obtained from the ecoinvent 3.2 database.

3.3 ECO-PROFILE

In the following tables, the environmental behavior of the G126-2.625 MW wind turbine from a life cycle perspective it is shown, in the separated phases that were described above. The results have been calculated using CML-IA impact assessment methodology (version 4.8 - August 2016). The EPD verifier had access to more comprehensive information on the LCA which supports this declaration.

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

"1 Kwh of electricity generated through an on-shore wind farm of Siemens-Gamesa G126 - 2.625 MW wind turbine generators, located in a European scenario and operating under low wind conditions (IEC III-a), and thereafter distributed to a 132 KV European electrical grid"

ECOPROFILE	UNIT	IEC IIIa Wind Class - European G126 2.625 MW Wind Farm						
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	Kg	3,789E-06	2,986E-06	5,850E-03	**5,857E-03**	1,288E-04	5,990E-05	**6,046E-03**
Iron	Kg	3,594E-07	1,996E-07	1,302E-03	**1,303E-03**	2,866E-05	7,152E-05	**1,403E-03**
Calcite	Kg	3,673E-07	2,672E-07	1,191E-03	**1,192E-03**	2,621E-05	2,940E-05	**1,248E-03**
Sodium chloride	Kg	4,725E-08	7,962E-08	1,966E-04	**1,967E-04**	4,328E-06	3,387E-06	**2,044E-04**
Gangue, bauxite	Kg	1,749E-07	7,565E-08	1,850E-04	**1,852E-04**	4,075E-06	3,013E-04	**4,906E-04**
Clay, unspecified	Kg	3,478E-07	6,721E-08	1,713E-04	**1,718E-04**	3,779E-06	1,552E-05	**1,911E-04**
Colemanite	Kg	8,718E-11	2,835E-11	7,536E-05	**7,536E-05**	1,658E-06	2,111E-10	**7,702E-05**
Nickel, in crude ore	Kg	2,046E-08	6,116E-09	6,107E-05	**6,109E-05**	1,344E-06	8,062E-07	**6,324E-05**
Chromium	Kg	7,935E-09	2,098E-09	2,345E-05	**2,346E-05**	5,160E-07	7,807E-08	**2,405E-05**
Magnesite	Kg	2,752E-09	1,525E-09	2,329E-05	**2,329E-05**	5,124E-07	4,116E-08	**2,384E-05**
Gypsum	Kg	6,983E-09	5,703E-09	1,790E-05	**1,792E-05**	3,941E-07	1,654E-07	**1,848E-05**
Aluminium	Kg	1,647E-08	7,126E-09	1,756E-05	**1,758E-05**	3,867E-07	2,837E-05	**4,634E-05**
Clay, bentonite	Kg	1,022E-08	2,724E-09	1,585E-05	**1,586E-05**	3,489E-07	8,592E-07	**1,707E-05**
Manganese	Kg	1,732E-09	9,651E-10	1,562E-05	**1,562E-05**	3,436E-07	3,157E-08	**1,600E-05**
Other non-renewable resources[4]	Kg	3,276E-07	1,718E-08	7,813E-05	**7,848E-05**	1,727E-06	2,688E-06	**8,290E-05**
Renewable material resources								
Wood	Kg	2,945E-07	3,717E-08	1,774E-04	**1,778E-04**	3,911E-06	7,221E-06	**1,889E-04**
Water use								
Total amount of water use	m3	2,671E-07	8,730E-08	5,537E-05	**5,573E-05**	1,226E-06	2,818E-06	**5,977E-05**
Direct amount of water used in the core process	m3	-	8,079E-09	-	**8,079E-09**	4,039E-11	-	**8,119E-09**
Non-renewable energy resources								
Nuclear	MJ	3,271E-05	2,350E-06	9,585E-03	**9,620E-03**	2,116E-04	2,055E-04	**1,004E-02**
Crude oil	MJ	1,169E-03	6,624E-05	4,973E-02	**5,096E-02**	1,121E-03	8,196E-04	**5,290E-02**
Brown coal	MJ	1,306E-05	1,272E-06	3,520E-03	**3,534E-03**	7,775E-05	3,690E-04	**3,981E-03**
Hard coal	MJ	3,605E-05	7,839E-06	2,816E-02	**2,820E-02**	6,204E-04	3,502E-03	**3,232E-02**
Natural gas	MJ	9,299E-05	9,652E-06	3,503E-02	**3,514E-02**	7,730E-04	9,153E-04	**3,683E-02**
Renewable energy resources								
Energy from hydro power	MJ	6,992E-06	9,257E-07	6,177E-03	**6,184E-03**	1,361E-04	5,558E-04	**6,876E-03**
Energy from biomass	MJ	1,535E-05	6,993E-07	3,610E-03	**3,626E-03**	7,978E-05	1,260E-04	**3,832E-03**
Wind electricity	MJ	1,885E-06	1,275E-07	5,153E-03	**5,155E-03**	1,134E-04	7,223E-06	**5,276E-03**
Solar electricity	MJ	1,999E-08	4,265E-09	5,514E-04	**5,514E-04**	1,213E-05	1,899E-08	**5,635E-04**
Electricity use in the wind farm[5]	Kwh	-	8,700E-03	-	**8,700E-03**	1,91E-04	-	**8,89E-03**
Recycled material resources								
Steel	g	-	-	6,418E-01	**6,418E-01**	1,412E-02	2,574E-02	**6,816E-01**
Aluminium	g	-	-	3,441E-02	**3,441E-02**	7,571E-04	1,889E-02	**5,407E-02**
Copper	g	-	-	3,165E-03	**3,165E-03**	6,963E-05	4,851E-04	**3,720E-03**

[4] Sum of 58 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	IEC IIIa Wind Class - European G126 2.625 MW Wind Farm						
POLLUTANT EMISSIONS		1 KWh electricity generated and distributed						
		Upstream	Core Process	Core Infrastructure	TOTAL GENERATED	Downstream Process	Downstream Infrastructure	TOTAL DISTRIBUTED
Potential environmental impacts								
Global warming potential (100yrs)	g CO_2 eq	2,209E-02	5,040E-02	8,759E+00	**8,831E+00**	1,943E-01	5,979E-01	**9,623E+00**
Acidification potential	g SO_2 eq	1,479E-04	2,395E-05	5,803E-02	**5,820E-02**	1,280E-03	4,084E-03	**6,356E-02**
Eutrophication potential	g PO_4^{3-} eq	3,266E-05	1,917E-05	2,635E-02	**2,640E-02**	5,808E-04	1,418E-03	**2,840E-02**
Formation of ground level ozone	g C_2H_4 eq	9,783E-06	1,114E-06	3,604E-03	**3,615E-03**	7,953E-05	2,873E-04	**3,982E-03**
Emissions to air contributing most to the environmental impact categories								
Carbon dioxide, fossil	g	1,942E-02	5,013E-02	7,816E+00	**7,885E+00**	1,735E-01	5,139E-01	**8,573E+00**
Methane, fossil	g	6,279E-05	7,476E-06	2,336E-02	**2,343E-02**	5,154E-04	2,211E-03	**2,615E-02**
Methane, biogenic	g	7,979E-07	8,801E-08	5,597E-03	**5,597E-03**	1,231E-04	3,569E-05	**5,756E-03**
Dinitrogen monoxide	g	6,732E-07	1,690E-07	3,095E-04	**3,103E-04**	6,827E-06	1,145E-05	**3,286E-04**
Carbon monoxide, fossil	g	3,559E-05	1,201E-05	5,385E-02	**5,390E-02**	1,186E-03	4,633E-03	**5,972E-02**
Sulfur dioxide	g	1,057E-04	1,037E-05	2,852E-02	**2,864E-02**	6,301E-04	2,851E-03	**3,212E-02**
Nitrogen oxides	g	5,630E-05	1,820E-05	3,958E-02	**3,966E-02**	8,724E-04	1,362E-03	**4,189E-02**
Ammonia	g	8,835E-07	3,175E-07	5,194E-04	**5,206E-04**	1,145E-05	2,650E-05	**5,586E-04**
Ethane	g	7,940E-07	7,225E-08	2,271E-04	**2,280E-04**	5,015E-06	9,999E-06	**2,430E-04**
Ethene	g	1,437E-07	8,890E-09	1,912E-05	**1,928E-05**	4,241E-07	1,164E-06	**2,086E-05**
Butane	g	1,548E-06	8,814E-08	7,646E-05	**7,810E-05**	1,718E-06	1,775E-06	**8,159E-05**
Benzene	g	3,005E-07	1,601E-07	3,794E-04	**3,798E-04**	8,357E-06	2,009E-05	**4,083E-04**
Pentane	g	1,908E-06	1,103E-07	9,577E-05	**9,779E-05**	2,151E-06	2,524E-06	**1,025E-04**
Ethanol	g	5,033E-09	1,329E-08	1,702E-04	**1,702E-04**	3,745E-06	6,953E-08	**1,740E-04**
Ethyl acetate	g	1,984E-08	7,542E-09	3,880E-04	**3,881E-04**	8,537E-06	1,148E-08	**3,966E-04**
Hexane	g	1,249E-06	4,454E-08	6,172E-05	**6,301E-05**	1,386E-06	1,033E-06	**6,543E-05**
Hydrogen chloride	g	9,704E-07	1,842E-07	5,174E-04	**5,186E-04**	1,141E-05	8,080E-05	**6,108E-04**
Hydrogen fluoride	g	1,517E-07	3,931E-08	1,007E-04	**1,009E-04**	2,219E-06	9,679E-05	**1,999E-04**
Methyl ethyl ketone	g	1,982E-08	1,048E-08	3,880E-04	**3,881E-04**	8,537E-06	1,152E-08	**3,966E-04**
Emissions to water contributing most to the environmental impact categories								
Phosphate	g	1,737E-05	1,159E-05	1,879E-02	**1,882E-02**	4,140E-04	1,168E-03	**2,040E-02**
COD, Chemical Oxygen Demand	g	2,661E-04	2,203E-04	6,281E-02	**6,329E-02**	1,392E-03	1,066E-03	**6,575E-02**
Nitrate	g	1,261E-05	1,175E-06	5,555E-03	**5,569E-03**	1,225E-04	3,611E-04	**6,052E-03**
Emissions of radioactive isotopes								
C-14	KBq	5,623E-07	3,258E-08	3,459E-05	**3,518E-05**	7,741E-07	7,373E-07	**3,670E-05**
Rn-222	KBq	1,138E-03	7,616E-05	2,723E-01	**2,735E-01**	6,017E-03	6,803E-03	**2,863E-01**
Kr-85	KBq	2,096E-08	1,013E-09	3,549E-06	**3,571E-06**	7,857E-08	1,094E-07	**3,759E-06**
Emissions of biogenic carbon dioxide								
Carbon dioxide, biogenic	g	7,712E-04	5,328E-05	2,600E-01	**2,609E-01**	5,739E-03	3,758E-03	**2,704E-01**

ECOPROFILE	UNIT	IEC IIIa Wind Class - European G126 2.625 MW Wind Farm						
POLLUTANT EMISSIONS		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	9,864E-06	3,026E-06	8,606E-03	**8,619E-03**	1,896E-04	7,183E-04	**9,527E-03**
Particulates, >10 um to air	g	1,008E-05	4,129E-06	1,067E-02	**1,068E-02**	2,350E-04	1,092E-03	**1,201E-02**
Particulates, >2,5 um, and <10 um to air	g	4,062E-06	1,832E-06	6,882E-03	**6,888E-03**	1,515E-04	4,463E-04	**7,486E-03**
PAH, polycyclic aromatic hydrocarbons to air	g	3,112E-09	9,245E-10	4,235E-06	**4,239E-06**	9,327E-08	1,596E-06	**5,928E-06**
PAH, polycyclic aromatic hydrocarbons to water	g	7,530E-09	4,703E-10	1,000E-06	**1,008E-06**	2,218E-08	1,820E-08	**1,048E-06**
Arsenic to air	g	5,357E-09	7,933E-10	1,272E-05	**1,273E-05**	2,800E-07	7,798E-07	**1,379E-05**
Cadmium to air	g	2,440E-09	3,008E-10	4,178E-06	**4,181E-06**	9,198E-08	2,609E-07	**4,534E-06**
Dioxins to air	g	4,446E-15	4,954E-14	1,246E-11	**1,251E-11**	2,753E-13	5,511E-13	**1,334E-11**
Emissions of oil to water and ground								
Oils, unspecified to water	g	7,998E-05	4,460E-06	3,078E-03	**3,163E-03**	6,958E-05	9,377E-05	**3,326E-03**
Oils, unspecified to soil	g	8,770E-05	4,886E-06	3,226E-03	**3,319E-03**	7,301E-05	5,885E-05	**3,450E-03**

ECOPROFILE	UNIT	IEC IIIa Wind Class - European G126 2.625 MW Wind Farm						
WASTE & MATERIAL SUBJECT TO RECYCLING		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	-	1,584E-02	-	**1,584E-02**	3,485E-04	3,336E-05	**1,622E-02**
Hazardous waste - To recycling	g	-	-	6,513E-03	**6,513E-03**	1,433E-04	-	**6,656E-03**
Hazardous waste - Radioactive								
Volume for deposit of low-active radioactive waste	m3	3,487E-12	1,954E-13	1,620E-10	**1,657E-10**	3,646E-12	3,143E-12	**1,725E-10**
Volume for deposit of radioactive waste	m3	2,030E-14	1,588E-15	5,090E-12	**5,112E-12**	1,125E-13	1,491E-13	**5,373E-12**
Other waste								
Non-hazardous waste - To landfill	g	-	-	4,396E+00	**4,396E+00**	9,671E-02	6,672E-05	**4,493E+00**
Non-hazardous waste - To recycling	g	-	-	1,380E+00	**1,380E+00**	3,035E-02	5,736E-03	**1,416E+00**

3.4 HOT SPOT ANALYSIS AND CONCLUSIONS

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

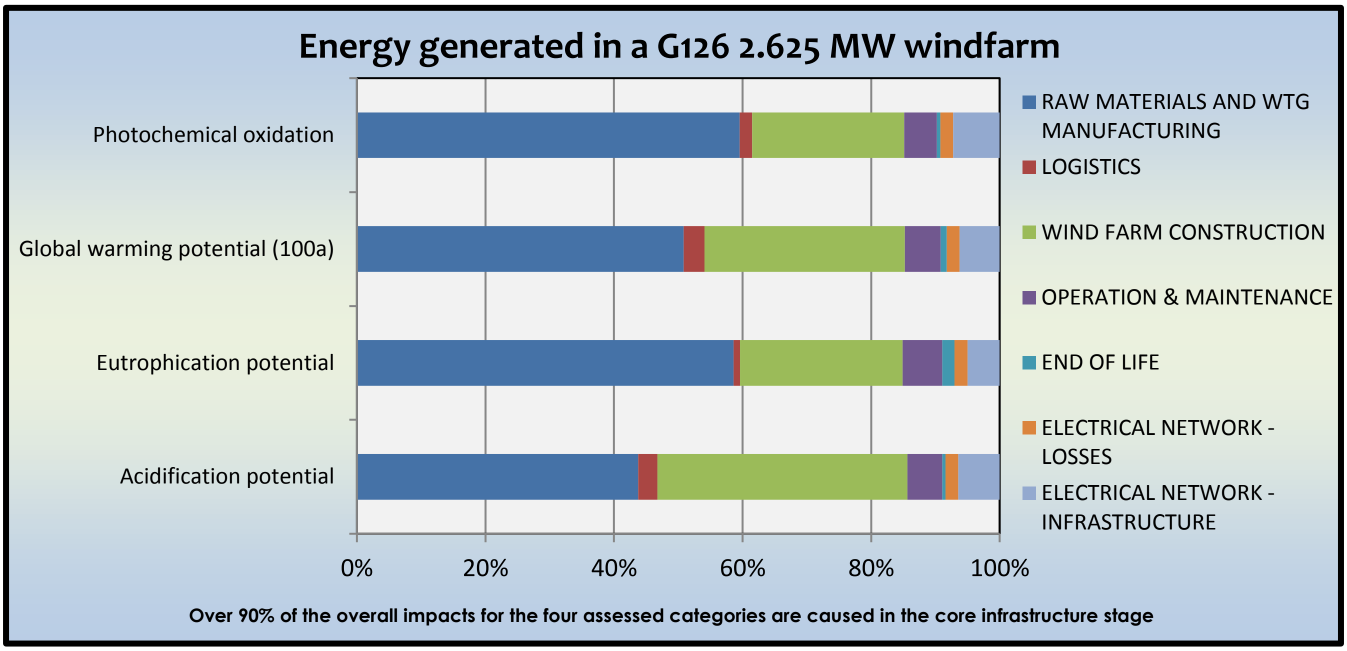

Figure 7.-Environmental hot spots

As shown in the figure above, there are two life cycle stages dominating the life cycle environmental impacts of the distributed energy. The wind farm construction stage together with the raw material and WTG manufacturing stage, are responsible for approximately the 83% of the total environmental impacts for the 4 assessed impact categories.

From a life cycle point of view, these two stages are the main hot-spots of the energy generated in the G126 2.625MW windfarm, and should be carefully designed in future projects.

Nearly the 53% (in average for the 4 impact categories) of the environmental impacts of the energy generated and distributed by a G126 2.625 MW WTG is caused in the raw material acquisition and WTG manufacturing phase. This is a logical consequence, since a wind turbine does not consume any fossil fuel during its operation as the conventional energy sources do, so the main environmental aspect of this technology is related to the manufacturing of its infrastructure. This is mostly caused by the raw materials needed to manufacture all the steel parts of the WTG and the subsequent machining phases. The most critical components in this phase are the tower and the blades.

Concerning the wind farm construction, this stage represents the 30% of the impacts (in average). The most relevant environmental aspects for the construction is the fuel burned in the construction machinery (hydraulic diggers, dumpers, lorries…), followed by the materials which compose the foundation (mainly concrete and steel).

Finally, 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 G126 2.625 MW WTGs. More detailed conclusions on the environmental impacts were made in the full LCA report. Please, refer to Siemens-Gamesa Renewable Energy 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.

Any possible environmental impacts are analyzed before the facilities are built by conducting a forecast and an assessment beforehand. Where an impact is significant, the project is changed as much as possible, the available technical improvements are made and the necessary measures to correct and minimize the impact are taken. If it cannot be completely mitigated, offsetting measures are taken.

4.1.1 Biodiversity studies

During 2016, 22 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.

	2016	2015	2014	2013	2012
Development stage					
Preliminary EIA	1	3	3	-	1
Archeology	-	-	-	3	-
Environmental impact studies (EIA)	2	2	7	12	12
Bird fauna and bats	2	-	1	39	15
Noise	2	2	3	15	1
Specific studies	2	-	3	38	9
Total development stage	**9**	**7**	**17**	**107**	**38**
Construction stage					
Environmental monitoring	3	2	-	10	5
Archeological monitoring	-	-	-	-	-
Others	3	1	-	1	-
Total construction stage	**6**	**3**	**-**	**11**	**5**
Operating stage					
Environmental monitoring	4	1	7	5	7
Others	3	1	2	7	-
Total operating stage	**7**	**2**	**9**	**12**	**7**
Total Biodiversity Studies	**22**	**12**	**26**	**130**	**50**

Table 5.- Biodiversity studies

4.1.2 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.

4.1.3 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 analyse the impact on vegetation the percentage of surface covered (PSC) indicator is used, which is calculated before and after the execution of works in order to determine its variation. This index suffers insignificant variations so that is concluded that the work only affects the vegetation units of lower ecological value, respecting the other units.

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

4.1.4 Analysis of protected or restored habitat

Gamesa has activities in some areas where threatened species included in the IUCN Red List and in other national conservation lists live or could be present. This, however, does not mean that they are affected or threatened by such activities.

Hence, the identification of species on the IUCN Red List and other species included in national conservation lists, which could be affected by Gamesa's activities, is vital to take the necessary measures to avoid endangering them. Gamesa's control on matters having to do with biodiversity, have identified the following species that are present in wind farms or high voltage lines, which have been classified by their risk of extinction:

Species	IUCN category	Affected by wind farm	Affected by high voltage line
Tetrax tetrax	NT	6	0
Neophron percnopterus	EN	5	1
Milvus milvus	NT	6	1
Marmoronetta angustirostris	VU	1	0
Sylvia undata	NT	5	4
Streptopelia turtur	VU	1	0
Chalcides bedriagai	NT	2	1
Vipera latastei	VU	2	3
Eliomys quercinus	NT	2	8
Numenius arquata	NT	0	1
Lutra lutra	NT	0	5
Oryctolagus cuniculus	NT	2	8
Timon lepidus	NT	2	5
Galemys pyrenaicus	VU	0	4
Arvicola sapidus	VU	0	8
Chioglossa lusitanica	VU	0	3
Iberian frog	NT	0	6
Lacerta schreiberi	NT	0	5
Achondrostoma arcasii	VU	0	2
Cyprinus carpio	VU	0	2
Anguilla anguilla	CE	0	5
Coracias garrulus	NT	0	2
Pelobates culprites	NT	2	0
Bombina pachypus	EN	1	0
Zamenis lineatus	DD	1	0
Elaphe quatuorlineata	NT	1	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

4.2 LAND USE

The Siemens-Gamesa G126 - 2.625 MW, is a relatively new machine and consequently there is no statistical data on G126 wind farms construction. For that reason, data from other wind farm installed in the most representative country have been chosen for the land use analysis. The site assessed represents a 9 WTG wind farm installed in Europe in a combination of forest and semi natural areas.

4.2.1 Description of land use - CORINE Land cover classes

An analysis of soil condition before and after wind farm installation is usually made in the Environmental Impact Studies (EIS) that are conducted after a wind farm project is approved. This wind farm is composed of 9 WTGs of 2.625 MW and it will be operational for 20 years. Land use before and after exploitation depending on the type of land is specified in the following table:

CORINE LAND COVER CLASSES	BEFORE (m^2)	AFTER (m^2)
1-ARTIFICIAL SURFACES		
1.2-INDUSTRIAL, COMMERCIAL AND TRANSPORT UNITS		
1.2.1-INDUSTRIAL OR COMMERCIAL UNITS	0.0	63,750.0
2-AGRICULTURAL AREAS		
3-FORESTS AND SEMI-NATURAL AREAS		
3.1-FORESTS		
3.1.2-CONIFEROUS FOREST	1,546,316.0	1,511,253.5
3.2-SHRUB AND/OR HERBACEOUS VEGETATION ASSOCIATIONS		
3.2.1-NATURAL GRASSLAND	322,599.2	313,674.2
3.2.2-MOORS AND HEATHLAND	148,949.9	143,849.9
3.2.4-TRANSITIONAL WOODLAND SHRUB	492,238.4	486,500.9
4-WETLANDS		
4.1-INLAND WETLANDS		
4.1.2-PEATBOGS	472,997.5	464,072.5
5-WATER BODIES		
TOTAL	**2,983,101.0**	**2,983,101.0**

Table 7.- Land use before and after exploitation

4.2.2 Description of the activities on the occupied areas

The area of land occupied is mainly composed of the following elements:

- Foundations
- Turbines
- Tracks / roads
- Control buildings
- Electrical substation compounds
- Trenches for internal wiring

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.

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

RADIOLOGY

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.

FIRE

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

SPILLS

The environmental management system currently in place at Gamesa prevents accidental spills through technical control elements (spill trays, loading and unloading areas, storage of chemical products, protection of the rainwater network, etc.), along with management mechanisms. Should spills happen, Gamesa is equipped with environmental anomaly detection, reporting and correction methods which are aimed at preventing this kind of episodes from being repeated.

Significant spills are construed as spills that cause damage to the facility's external surroundings and require giving notice to the appropriate public administration. In case a significant spill occurs, it would be recorded, notified and corrected in accordance with internal management processes.

In the following table such impacts are quantified by the quantity of substances released as a result of the incidents by Kwh. The right column shows the emissions and consequences under normal conditions.

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

Table 8.- Environmental risks

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

4.4 ELECTROMAGNETIC FIELDS

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

Additionally, and coming from the EMC Directive (2004/108/EC) (Electromagnetic Compatibility Directive), it is worth noting that EN 62311 and EN 62479 (included in the harmonised standards list for the LV Directive) cover human exposure restrictions for electromagnetic fields, and are relevant to WTG design. These two standards were taken into account in the specifications of the machine, whose design is validated against these requirements so it can be said 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 the nacelle mechanical noise exists, it is low compared to aerodynamic noise, and at ground level, the only relevant noise is the aerodynamic one.

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

Nevertheless, for locations with strict noise requirements, low noise operation modes are available. 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 establishing 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.

According to the measures carried out according to IEC 61400-14: 2005 and IEC 61400-11; 3rd Ed.; noise level is lower than 107,2 dBA.

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.

In many cases, as part of the assessment process, interactive maps are used to illustrate the potential effects of the wind turbines. These maps allow viewing the theoretical visibility of the proposed turbines, zooming into an area and viewing photomontages from some particular viewpoints in the surrounding area to see what the wind farm would look like.

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 Tecnalia R&I Certificación, accredited certification body by ENAC (the Spanish National Accreditation Body) and 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 3.0 for CPC 171 & 173: Electricity, Steam, and Hot and Cold Water Generation and Distribution, valid until 2019-02-05.

This certification is valid until 2020-06-21.

5.2 MANDATORY STATEMENTS

GENERAL

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

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.

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).

RESPONSIBILITY OF THE VERIFIER AND THE PROGRAMME OPERATOR

The verifier and the programme operator do not make any claim nor have any responsibility of the legality of the product.

5.2.1 Information on verification

INFORMATION ABOUT THE CERTIFICATION BODY	
EPD programme	EPD International AB Box 210 60, SE-100 31 Stockholm, Sweden www.environdec.com
Registration Nº	**S-P-01048**
Date of publication	**2017-06-21**
EPD validity	**2020-06-21**
EPD valid within the following geographical area	This EPD has European validity
EPD type	Cradle-to-grave
Independent verification of the declaration and data, according to ISO 14025:2006	☒External verification ☐EPD Process certification
Third party verifier	Tecnalia R&I Certificación, S.L. Auditor: Elisabet Amat eli.amat@tecnaliacertificacion.com
Third party verifier accredited or approved by	ENAC. Accreditation no.125/C-PR283
LCA study developed by	IK Ingenieria
Reference Product Category Rules (PCR)	PCR 2007:08 UN CPC 171 & 173 Version 3.0 Electricity, steam and hot/cold water generation and distribution
PCR review conducted by	The Technical Committee of the International EPD® System Full list of TC members available on www.environdec.com/TC
PCR prepared by	The Technical Committee of the International EPD® System PCR Moderator: Mikael Ekhagen - VATTENFALL Contact via Mikael.ekhagen@vattenfall.com

SIEMENS Gamesa RENEWABLE ENERGY

Parque Tecnológico de Bizkaia, Ed. 222
48170 Zamudio (Vizcaya) – Spain

Phone number: +34 944 317 600
e-mail: media@gamesacorp.com
Web: www.gamesacorp.com/gamesa/es/siemensgamesa.html

6. LINKS AND REFERENCES

Additional information about Siemens-Gamesa Renewable Energy:

www.gamesacorp.com/gamesa/es/siemensgamesa.html

www.siemens.com/global/en/home/markets/wind.html

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

www.gamesacorp.com/en/products-and-services/wind-turbines/g2mw.html

Additional information about the International EPD® System:

www.environdec.com

- General instructions of the programme:

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 3.2 Database, published by the Swiss Centre for Life Cycle Inventories

http://www.ecoinvent.org

Other references:

- Red eléctrica española – www.ree.es
- Comisión Nacional de la Energía – www.cne.es
- Eurelectric – www.eurelectric.org
- 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
- 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