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IMPIANTO DI PRODUZIONE DI ENERGIA DA FONTE EOLICA "Parco Eolico San Pietro" DI POTENZA PARI A 60 MW

REGIONE PUGLIA
PROVINCIA di BRINDISI

PARCO EOLICO E RELATIVE OPERE DI CONNESSIONE NEI COMUNI DI:
Brindisi, San Pietro Vernotico, Cellino San Marco

PROGETTO DEFINITIVO
Id AU VSSK6Y3

Tav.: R39.6

Titolo:

MiTE Richiesta Integrazioni (prot. n. 0002686-24.05.2021) 6. Compensazione

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6 COMPENSAZIONE

6.1 Emissioni dovute alle fasi di produzione dei materiali e alla messa in opera dell’impianto

RICHIESTAMiTE

Non risultano adeguatamente contabilizzate le emissioni dovute alle fasi di produzione dei materiali (calcestruzzo, metalli, …) e alla messa in opera dell’impianto, valutate in ottica di ciclo di vita che dovranno essere opportunamente compensate.

RISCONTRO

Nel presente capitolo si effettuerà una stima delle emissioni di polveri determinate da movimenti di terra e dai trasporti lungo la viabilità di servizio non asfaltata durante la costruzione, inclusi quelli necessari per il conferimento in cantiere dei componenti dell’impianto e degli altri materiali necessari (cemento, acciaio, misto di cava). Nel capitolo successivo saranno approfonditi gli aspetti relativi ai materiali dei componenti di impianto in ottica di ciclo di vita.

Le emissioni vengono stimate a partire da una valutazione quantitativa delle attività svolte nei cantieri, utilizzando opportune fattori di emissione riportati in “Compilation of air pollutant emission factors” – E.P.A. - Volume I, Stationary Point and Area Sources (Fifth Edition)” e riportati nella delibera della GP n.213/2009 e nelle Nuove Linee Guida sulle attività pulverulente.

In particolare si farà riferimento alle attività/situazioni che possono originare emissioni diffuse di polveri secondo quanto indicato nelle “**Linee guida per la valutazione delle emissioni di polveri provenienti da attività di produzione, manipolazione, trasporto, carico o stoccaggio di materiali polverulenti**” elaborate da ARPAT-AF Modellistica previsionale, riportate da Barbaro A. et al. (2009) [1] .

Transito di mezzi su strade non asfaltate

Per la fase operativa di calcolo dell’emissione di particolato PM10 dovuto al transito dei mezzi su strade non asfaltate si ricorre al modello emissivo proposto nel paragrafo 13.2.2 ”Unpavedroads” dell’AP-42..

Si procede quindi con il calcolo del *fattore emissivo* ***EF*** dovuto al passaggio di ciascun mezzo secondo:

$$EF\left(\frac{kg}{km}\right) = k \cdot \left(\frac{S}{12}\right)^{a} \cdot \left(\frac{W}{3}\right)^{b}$$

Dove, nel caso di calcolo del particolato PM10, abbiamo (secondo Barbaro et all. 2009):

k=0,423

a= 0,9

b=0,45

Il valore del parametro **s** risulta proporzionale al contenuto di limo (*silt*) del suolo, inteso come particolato di diametro inferiore a 75 µm. Poiché la stima di questo parametro richiede procedure tecniche e analitiche precise, in mancanza di informazioni specifiche viene suggerito di utilizzare un valore compreso tra 12-22%; considerando la natura delle strade di percorrenza si è scelto di utilizzare un **valore di silt pari a 20%**, come ulteriore fattore cautelativo di sicurezza, in definitiva porremo:

s= 20%

Il parametro **w** è il peso dei mezzi di trasporto calcolato come media tra veicolo vuoto (ritorno) e a pieno carico (andata). Per il progetto in esame si assume

W= 60 tonnellate per il trasporto dei componenti degli aerogeneratori

W= 15 tonnellate per tutti gli altri mezzi di trasporto (betoniere, camion, gru, mezzi di trasporto componenti elettromeccanici in SSE).

Assunti tali parametri otteniamo per ciasun aerogeneratori i valori di EF riportati in tabella

Sostituendo nella formula sopra riportata i valori di k, a, b, s, w come definiti, otteniamo i seguenti valori di EF:

- **EF= 0,041 kg/km** per il trasporto dei componenti degli aerogeneratori;
- **EF= 0,022 kg/km** per tutti gli altri mezzi di trasporto e mezzi di trasporto componenti elettromeccanici in SSE

Dopo aver determinato il fattore emissivo EF, si procede con **il calcolo dell'emissione finale E**, secondo la formula estratta da Barbaro et all. 2009:

$$E\left(\frac{kg}{h}\right) = EF \cdot kmh$$

Dove **kmh** è la lunghezza del percorso di ciascun mezzo riferito all'unità di tempo (kmh [km/h]), calcolato come come prodotto del doppio della lunghezza del tratto non asfaltato (considerando la tratta andata/ritorno) per il numero di trasporti riferiti alla tipologia di trasporto considerato, diviso per le ore lavorative giornaliere.

kmh= (2 x lunghezza percorso non asfaltato x numero trasporti) / ore lavorative giorno

Tale valore è specifico per ciascun aerogeneratore poiché dipende dalla lunghezza del tratto stradale non asfaltato per raggiungere l'aerogeneratore stesso. Ma dipende anche dal peso del mezzo utilizzato per il trasporto per ciascuna tipologia di trasporto effettuato.e diverso da aerogeneratore a aerogeneratore (specifico per ciascun aerogeneratore). La lunghezza è moltiplicata per due per tener conto del percorso di andata e di ritorno. Il procedimento di misura è stato ripetuto anche per la sottostazione elettrica.

1. La lunghezza dei tratti non asfaltati varia a seconda dell'aerogeneratore considerato ed è stata misurata, per ciascun aerogeneratore, sulla planimetria di progetto in cui sono riportate le strade di cantiere (*VSSK6Y3_ElaboratoGrafico_1_06a_Strade di cantiere*), a partire dai punti di accesso all'area di progetto.
2. Il numero di trasporti per tipologia:
   a. Trasporto componenti di impianto pari a 12 per ciascun aerogeneratore
   b. Trasporto armature plinti di fondazione pari a 10 per ciascun aerogeneratore
   c. Trasporto calcestruzzo per realizzazione dei plinti di fondazione pari a 182 per aerogeneratore
   d. Trasporto componenti gru principale pari a 20 per ciascuna aerogeneratore
   e. Trasporto componenti elettromeccanici in SSE pari a 30
3. Le ore lavoratice giornaliere sono 8, tranne per il trasporto del calcestruzzo che può durare anche 12 ore dal momento che si tratta di un getto continuo che non può essere interrotto

Dai valori di EF e kmh è possibile calcolare la E_{PM10} ovvero flusso di massa delle polveri emesse per **ciascuna tipologia di trasporto**, **per ciascun aerogeneratore** e **per la sottostazione**.

	CALCOLO EMISSIONE PM10 PER TRASPORTO COMPONENTI AEREGENERATORI							
		a	b	c	d=(axb)/c	e	f=dxe	
	Tratti non asfaltati [km]	andata/ritorno [km]	n trasporti componenti	ore lavorative	*kmh [km/h]*	*EF_PM10 [kg/km]*	*E_PM10 [g/h]*	*Valori di soglia assoluta PM10 accettabili [g/h]*
SPV01	3,000	6,000	12	8	9,00	0,041	369,00	2044
SPV02	2,200	4,400	12	8	6,60	0,041	270,60	1492
SPV03	1,850	3,700	12	8	5,55	0,041	227,55	1492
SPV04	0,700	1,400	12	8	2,10	0,041	86,10	628
SPV05	1,150	2,300	12	8	3,45	0,041	141,45	1492
SPV06	0,550	1,100	12	8	1,65	0,041	67,65	1492
SPV07	1,200	2,400	12	8	3,60	0,041	147,60	1492
SPV08	3,000	6,000	12	8	9,00	0,041	369,00	2044
SPV09	2,400	4,800	12	8	7,20	0,041	295,20	2044
SPV10	1,300	2,600	12	8	3,90	0,041	159,90	208

	CALCOLO EMISSIONE PM10 PER TRASPORTO CALCESTRUZZO PLINTI FONDAZIONE WTG							
		a	b	c	d=(axb)/c	e	f=dxe	
	Tratti non asfaltati [km]	andata/ritorno [km]	n trasporti componenti	ore lavorative	*kmh [km/h]*	*EF_PM10 [kg/km]*	*E_PM10 [g/h]*	*Valori di soglia assoluta PM10 accettabili [g/h]*
SPV01	3,000	6,000	182	12	91,00	0,022	2002,00	2044
SPV02	2,200	4,400	182	12	66,73	0,022	1468,13	1492
SPV03	1,850	3,700	182	12	56,12	0,022	1234,57	1492
SPV04	0,700	1,400	182	12	21,23	0,022	467,13	628
SPV05	1,150	2,300	182	12	34,88	0,022	767,43	1492
SPV06	0,550	1,100	182	12	16,68	0,022	367,03	1492
SPV07	1,200	2,400	182	12	36,40	0,022	800,80	1492
SPV08	3,000	6,000	182	12	91,00	0,022	2002,00	2044
SPV09	2,400	4,800	182	12	72,80	0,022	1601,60	2044
SPV10	1,300	2,600	182	12	39,43	0,022	867,53	208

	CALCOLO EMISSIONE PM10 PER TRASPORTO ARMATURE PLINTI FONDAZIONE WTG							
		a	b	c	d=(axb)/c	e	f=dxe	
	Tratti non asfaltati [km]	andata/ritorno [km]	n trasporti componenti	ore lavorative	*kmh [km/h]*	*EF_PM10 [kg/km]*	*E_PM10 [g/h]*	*Valori di soglia assoluta PM10 accettabili [g/h]*
SPV01	3,000	6,000	10	8	7,50	0,022	165,00	2044
SPV02	2,200	4,400	10	8	5,50	0,022	121,00	1492
SPV03	1,850	3,700	10	8	4,63	0,022	101,75	1492
SPV04	0,700	1,400	10	8	1,75	0,022	38,50	628
SPV05	1,150	2,300	10	8	2,88	0,022	63,25	1492
SPV06	0,550	1,100	10	8	1,38	0,022	30,25	1492
SPV07	1,200	2,400	10	8	3,00	0,022	66,00	1492
SPV08	3,000	6,000	10	8	7,50	0,022	165,00	2044
SPV09	2,400	4,800	10	8	6,00	0,022	132,00	2044
SPV10	1,300	2,600	10	8	3,25	0,022	71,50	208

	CALCOLO EMISSIONE PM10 PER TRASPORTO COMPONENTI GRU PRINCIPALE							
		a	b	c	d=(axb)/c	e	f=dxe	
	Tratti non asfaltati [km]	andata/ritorno [km]	n trasporti componenti	ore lavorative	*kmh [km/h]*	*EF_PM10 [kg/km]*	*E_PM10 [g/h]*	*Valori di soglia assoluta PM10 accettabili [g/h]*
SPV01	3,000	6,000	20	8	15,00	0,022	330,00	2044
SPV02	2,200	4,400	20	8	11,00	0,022	242,00	1492
SPV03	1,850	3,700	20	8	9,25	0,022	203,50	1492
SPV04	0,700	1,400	20	8	3,50	0,022	77,00	628
SPV05	1,150	2,300	20	8	5,75	0,022	126,50	1492
SPV06	0,550	1,100	20	8	2,75	0,022	60,50	1492
SPV07	1,200	2,400	20	8	6,00	0,022	132,00	1492
SPV08	3,000	6,000	20	8	15,00	0,022	330,00	2044
SPV09	2,400	4,800	20	8	12,00	0,022	264,00	2044
SPV10	1,300	2,600	20	8	6,50	0,022	143,00	208

	CALCOLO EMISSIONE PM10 PER TRASPORTO COMPONENTI ELETTROMECCANICI IN SSE							
		a	b	c	d=(axb)/c	e	f=dxe	
	Tratti non asfaltati [km]	andata/ritorno [km]	n trasporti componenti	ore lavorative	*kmh [km/h]*	*EF_PM10 [kg/km]*	*E_PM10 [g/h]*	*Valori di soglia assoluta PM10 accettabili [g/h]*
SSE	0,400	0,800	30	8	3,00	0,022	66,00	2044

In Tabella i valori di E_{PM10} sono calcolati in g/h per poter effettuare il confrono con i valori di soglia accettabili, come di seguito valutati.

Una volta stimati i flussi totali di polveri per una data lavorazione, se ne valutano gli effetti confrontando il valore E_{PM10} con le soglie indicate nelle Linee guida. Si riporta in *Figura 1* la "Tabella 13" estratta da Barbaro et al., 2009, con le proposte di soglie assolute di PM10 al variare della distanza dalla sorgente ed al variare del numero di giorni di emissione.

Tabella 13 proposta di soglie assolute di emissione di PM10 al variare della distanza dalla sorgente e al variare del numero di giorni di emissione (i valori sono espressi in *g/h*)

Intervallo di distanza (*m*)	Giorni di emissione all'anno					
	>300	300 ÷ 250	250 ÷ 200	200 ÷ 150	150 ÷ 100	<100
0 ÷ 50	145	152	158	167	180	208
50 ÷ 100	312	321	347	378	449	628
100 ÷ 150	608	663	720	836	1038	1492
>150	830	908	986	1145	1422	2044

Figura 1: Soglie assolute di emissione di PM10, estratte da Barbaro et al., 2009.

Nella prima colonna della tabella si riporta la distanza tra sorgente che emette le polveri e il recettore.

Nel nostro caso il numero di giorni di emissione dipende dalla tiopologia di trasporto ed è così stimato sulla base dell'esperienza per cantieri della stessa tipologia:

1. Trasporti componenti aerogeneratori: si stima abbiano una durata massima di 3 giorni per aerogeneratore
2. Trasporto armature plinti di fondazione: si stimano al più 10 giorni per aerogeneratore
3. Trasporto calcestruzzo per plinti di fondazione: 1 giorno per aerogeneratore poiché si tratta di un getto continuo
4. Trasporto componenti gru principale: 2 giorni per aerogeneratore
5. Trasporto compoineti elettromeccanici in SSE: si stimano al più 10 giorni

E' evidente pertanto che il numero di giorni di emissione è in tutti i casi minore di 100 e pertanto ci si dovrà riferire all'ultima colonna della Tabella in Figura 1.

Dalla planimetrie di progetto si evince che le distanze minime dei recettori dalle strade non asfaltate sono le seguenti, suddivise per strade di accesso a ciascun aerogeneratore.

In tabella si riportano infine i **valori soglia assoluta di emissione di PM10** accettabili in relazione alla distanza tra recettore e sorgente di emissione, così come indicato in Tabella di Figura 1

	distanza recettore [m]	soglia PM10 [g/h]
SPV01	>160	2044
SPV02	>120	1492
SPV03	>120	1492
SPV04	70	628
SPV05	>120	1492
SPV06	>120	1492
SPV07	>120	1492
SPV08	>160	2044
SPV09	>160	2044
SPV10	~40	208
SSE	**>120**	2044

Valutazione di accettabilità

Trasporto componenti aerogeneratori

I risultati delle simulazioni condotte riportano **tutti livelli emissivi accettabili**, poiché al di sotto dei valori di soglia riportati in Figura 1, in tutti i siti previsti (*SPV01, SPV02, SPV03, SPV04, SPV05, SPV06, SPV07, SPV08, SPV09, SPV10*)

Trasporto armature plinti di fondazione aerogeneratori

I risultati delle simulazioni condotte riportano **tutti livelli emissivi accettabili**, poiché al di sotto dei valori di soglia riportati in Figura 1, in tutti i siti previsti (*SPV01, SPV02, SPV03, SPV04, SPV05, SPV06, SPV07, SPV08, SPV09, SPV10*)

Trasporto componenti gru principale

I risultati delle simulazioni condotte riportano **tutti livelli emissivi accettabili**, poiché al di sotto dei valori di soglia riportati in Figura 1, in tutti i siti previsti (*SPV01, SPV02, SPV03, SPV04, SPV05, SPV06, SPV07, SPV08, SPV09, SPV10*)

Trasporto componenti elettromeccanici in SSE

I risultati delle simulazioni condotte riportano **tutti livelli emissivi accettabili**, poiché al di sotto dei valori di soglia riportati in Figura 1, in SSE.

Trasporto calcestruzzo plinti di fondazione aerogeneratori

Diversamente, per il trasporto del calcestruzzo, relativo al transito delle betoniere si riscontrano valori emissivi accettabili per i siti *SPV01, SPV02, SPV03, SPV04, SPV05, SPV06, SPV07, SPV08, SPV09* (evidenziati in verde) **e valori inaccettabili per il sito *SPV10*** (evidenziato in rosso nella tabella di riferimento).

In tal caso sono richieste particolari attività di monitoraggio.

La Masseria "**Giardino Monsignore**", è situata a circa 40 metri da un'area di manovra non asfaltata, utilizzata per giungere al sito SPV10. In tal caso è **necessaria l'applicazione di eventuali sistemi di controllo e/o mitigazione delle polveri emesse**, come proposto nelle Linee guida.

Sistemi di controllo o abbattimento

Dopo aver effettuato la valutazione sulle emissioni di particolato dovute al transito di mezzi su strade non asfaltate riguardanti le aree di cantiere, occorre apportare delle misure di controllo o abbattimento alle aree che producono una quantità di particolato oltre i limiti di emissione. Come riportato precedentemente, l'area che eccede la soglia di particolato emesso è quella riguardante l'area di manovra percorsa dai mezzi per giungere all'aerogeneratore SPV10.

La misura di mitigazione scelta è il trattamento della superficie con bagnamento (*wet suppression*). I costi sono moderati, ma richiedono applicazioni periodiche e costanti. Inoltre occorre considerare un sistema di monitoraggio per verificare che il trattamento venga effettuato.

Il valore determinato è **l'Efficienza di abbattimento del bagnamento (C %)**. Tale valore si ottiene dalla "Tabella11", estratta dalle Linee guida e riportata come *Figura 2*, a partire dai seguenti parametri:

- Traffico medio orario ***trh*** (h^{-1})
- Potenziale medio dell'evaporazione giornaliera ***P*** (*mm/h*)
- Quantità media del trattamento applicato ***I*** *(l/m^2)*
- Intervallo di tempo che intercorre tra le applicazioni ***τ*** *(h)*

Il traffico medio orario ***trh*** è stato determinato come il rapporto tra il numero di trasporti di calcestruzzo giornalieri riferiti all'aerogeneratore SPV10 sulle 12 h utili allo specifico trasporto.

Per quanto riguarda il potenziale medio dell'evaporazione giornaliera **P**, considerando la difficoltà nel ricavare dati reali, si assume come riferimento il valore medio annuale del caso-studio riportato nel rapporto EPA (1998a) pari a 0.34 mm/h.

Affinché la misura di mitigazione sia efficace a ridurre il particolato prodotto entro i valori di soglia si è scelta una quantità media I pari a 0.5 l/m^2 ogni 3 h tra due applicazioni successive.

Si ottiene quindi **un'efficienza di abbattimento del bagnamento C pari all'80%** pari a 691,04 g/h di PM10 abbattuti con un residuo di 172,76 g/h che entro la soglia dei 208 g/h.

Tabella 11 Intervallo di tempo in ore tra due applicazioni successive $\tau(h)$ per un valore di *trh* >10

Efficienza di abbattimento **Quantità media del trattamento applicato I (l/m²)**	**50%**	**60%**	**75%**	**80%**	**90%**
0.1	2	1	1	1	1
0.2	3	3	2	1	1
0.3	5	4	2	2	1
0.4	7	5	3	3	1
0.5	8	7	4	3	2
1	17	13	8	7	3
2	33	27	17	14	7

Figura 2: Intervallo di tempo in ore, estratto da Barbaro et al.,2009.

Ad ogni modo aldilà delle stime sopra effettuate e ai superamenti dei valori di soglia previsti, la bagnatura di strade e piazzole sarà comunque effettuata durante la fase di cantiere qualora ritenuta necessaria per attenuare l'effetto di spargimento delle polveri. Ciò soprattutto in relazione alle condizioni metereologiche ed al perido in cui avverrà la costruzione dell'impianto. E' evidente che le polveri generano una interferenza sull'ambiente circostante sopratutto nel periodo estivo, mentre la loro diffusione è limitata nel periodo autunno vernino.

Riferimenti

[1] (*Barbaro A., Giovannini F., Maltagliati S. (2009; in: Provincia di Firenze, ARPA Toscana, 2009). Allegato 1 alla d.g.p. n.213/009 "linee guida per la valutazione delle emissioni di polveri provenienti da attività di produzione, manipolazione, trasporto, carico e stoccaggio di materiali polverulenti*).

6.2 Analisi della fase di fine vita dell'impianto (LCA)

RICHIESTA MiTE

In riferimento agli aerogeneratori, si ritiene necessario approfondirne le caratteristiche costruttive e le modalità di scelta dei materiali, con particolare attenzione alle valutazioni effettuate in ottica di ecodesign e di economia circolare per favorirne la durata (Increased life time), lo smontaggio (Design for disassembling), il riuso o il riciclo a fine vita (Improved recyclability). In particolare, dato che il riuso potrà coinvolgere però solo una parte della quantità di aerogeneratori dismessi, si ritiene necessario utilizzare approcci innovativi per il riciclo dei materiali stessi degli aerogeneratori ed effettuare valutazioni accurate relativamente alla scelta dei materiali facendo riferimento alle più recenti ricerche nel settore (Accelerating Wind Turbine Blade Circularity, WindEurope, Cefic and EuCIA, May 2020)

RISCONTRO

All'interno del Quadro Progettuale SIA (VSSK6Y3_StudioFattibilitaAmbientale_34b), ai fini della valutazione degli impatti ambientali, nell'ottica primaria di procedere ad un *revamping* dell'impianto allo scadere della validità ventennale dell'Autorizzazione Unica ex D.lgs 387/03, titolo per la costruzione ed esercizio dell'impianto eolico nella Regione Puglia, viene presentato il piano di dismissione dell'impianto con delineate le fasi principali divise per attività che comprendo lo smontaggio, l'allontanamento dal sito, il recupero o il trasporto a rifiuto, degli elementi strutturali dell'impianto (plinti di fondazione, piste di esercizio, piazzole) e di tutti i componenti dell'aerogeneratore, in particolare quelle delle apparecchiature elettriche ed elettroniche. A tal riguardo si è fatto riferimento alle indicazioni della Direttiva 2012/19/UE sui rifiuti di apparecchiature elettriche ed elettroniche (RAEE) che prevede lo smontaggio ed il recupero dei materiali riutilizzabili dai componenti elettronici ed il trasporto a rifiuto di quelli non riutilizzabili.

Riguardo lo smontaggio effettivo degli aereogeneratori nell'ottica del riuso *"È praticamente certo che una volta smontati le navicelle, le pale del rotore, l'hub, i tronchi di torre tubolare saranno avviati in una officina specializzata per la rigenerazione di tutti i componenti sia meccanici sia elettrici, per poi essere rivenduti sul mercato degli aerogeneratori usati.".* Tale prassi che ha ovviamente un fondamento economico finisce per avere utilità anche in ottica di salvaguardia ambientale.

In questo capitolo si intende approfondire, in riferimento agli aerogeneratori le caratteristiche costruttive in termini di materiali impiegati ed implementarne la fase di "fine vita" (*Decomissioning*) dell'impianto in progetto con l'obiettivo di favorire l'Economia Circolare, rispettando il principio delle 4R (*Reduce, Reuse, Recycle, Recover*).

Nel presente documento vengono quindi ipotizzati degli scenari di dismissione, prevedendo cioè un riuso/riciclo dei componenti/materiali (*Closing the loops*) facendo riferimento alle più recenti ricerche nel settore.

SIEMENS GAMESA progettista, produttore e fornitore degli aerogeneratori ovvero di macchine per la produzione di energia da fonte rinnovabile, ritiene essenziale conoscere in toto i principali impatti ambientali dei suoi prodotti ed in quanto tale sta procedendo nella Certificazione Ambientale di Prodotto di Tipo III (International EPD Consortium) definita secondo ISO 14025, basata sulla metodologia LCA.

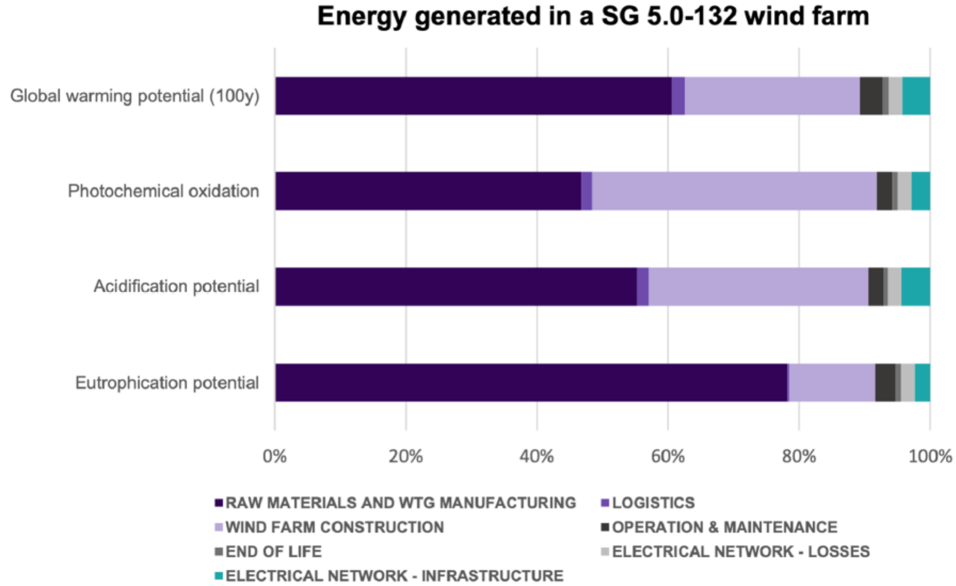
L' analisi del ciclo di vita (LCA) permette la scomposizione degli input e degli output in prodotti elementari ed in quanto tale consente di limitare/minimizzare l'impatto ambientale del prodotto lungo l'intero ciclo di vita.

Inoltre, SIEMENS GAMESA è un membro fondatore del Centro Basco **Ecodesign**, la cui missione è di favorire lo sviluppo di idee e attività imprenditoriali attraverso l'eco-design, migliorando competitività e prevenzione dei danni all'ambiente.

Valutazione EPD

Come anticipato in premessa, il produttore prescelto SIEMENS GAMESA ha completato le analisi EPD (Environmental Product Declaration in accordo alla norma ISO 14025) e LCA (Life Cycle Assessment) per il modello da 5 MW (132 m di diametro del rotore) e per il modello offshore da 8 MW (167 m di diametro), riportate come allegati a fine documento. E' ovvio che si prevede che questa analisi sarà ben presto estesa a tutti gli aerogeneratori della gamma. Avendo a disposizione dati riferiti a questi modelli di aerogeneratore, simili a quelli di progetto, si farà riferimento ad essi.

Di seguito si riportano in sintesi gli elementi fondamentali delle analisi condotte dal produttore, cominciando dal seguente grafico.



Come risulta evidente, ci sono due fasi del ciclo di vita che determinano il maggior impatto ambientale del ciclo di vita di un parco eolico. La fase di costruzione del parco eolico, insieme alla materia prima e alla fase di produzione WTG, è responsabile di circa l'89% dell'impatto ambientale totale per le 4 categorie di impatto indicate.

In media per le 4 categorie di impatto, quasi il 60% degli impatti ambientali associabili all'energia generata e distribuita da una turbina eolica sono causati nella fase di acquisizione delle materie prime e produzione delle turbine. Questa è una conseguenza logica, poichè una turbina eolica non consuma combustibile fossile durante il suo funzionamento come fanno le fonti energetiche convenzionali, quindi l'aspetto ambientale principale di questa tecnologia è legato alla realizzazione del manufatto e della relativa infrastruttura. Ciò è dovuto principalmente alle materie prime necessarie per produrre tutte le parti in acciaio della turbina e alle successive fasi di lavorazione. I componenti più·critici in questa fase sono la torre e l'impianto elettrico. Per quanto riguarda la costruzione del parco eolico, questa fase rappresenta il 29,2% degli impatti (in media). Gli aspetti ambientali più rilevanti per la fase di costruzione sono l'uso di mezzi e attrezzature e il consumo di materiale durante la costruzione delle fondamenta e le operazioni di movimento terra.

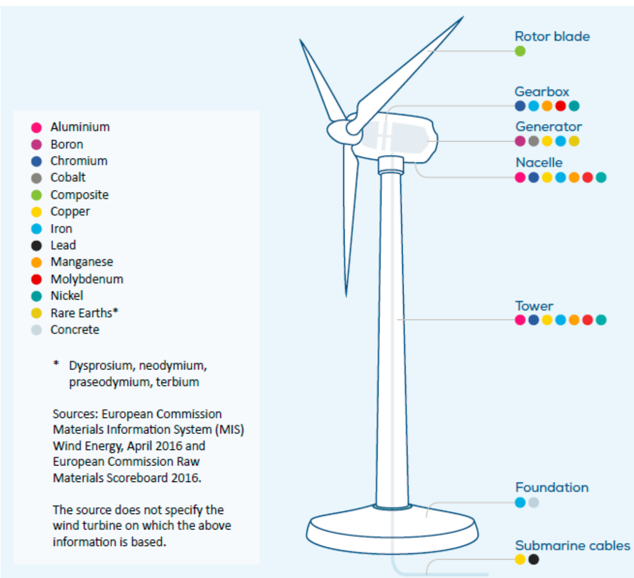
Infine, l'utilizzo e la manutenzione, il fine vita, le perdite elettriche nella rete e la logistica, hanno un contributo minore agli impatti ambientali del ciclo di vita dell'energia generata e distribuita.

Nella EPD della turbina offshore si specifica che l'"energy payback time" è di soli 7,4 mesi, potendo quindi affermare che per un parco onshore questo periodo è certamente inferiore, confermando che un parco eolico è caratterizzato da un vantaggio assoluto in termini di emissioni e impatti rispetto a qualsiasi altra fonte energetica.

Caratteristiche costruttive, materiali utilizzati ed ipotesi fine vita

Nell'immagine sottostante (figura) vengono presentati i materiali costituenti un generatore tipo che se confrontata con "l'ipotesi di fine vita" dei principali materiali costituenti permette di definire come l'energia eolica genera limitatissime quantità di materiali/componenti destinati a rifiuto (landfilled).

Per operare questo tipo di confronto viene riportata "l'ipotesi di fine vita" di un impianto onshore "SG 5.0-132 wind turbines", strutturata da Gamesa Siemens (fornitore dell'impianto in progetto) che differisce dal WTG in progetto solo in termini di dimensionamento del generatore.



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	90 % 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

Fonti: Somo 2018 – Human Rights in Wind Turbine Supply Chains(sx); Electricity from a European onshore wind farm using SG 5.0-132 wind turbines

Sintetizzando si osserva che:

- La torre, il mozzo, l'albero, il cambio, i telai e tutti i metalli sono recuperati per il riciclaggio (95%);
- Gli elementi elettrici ed elettronici (90% per i cavi e 75% per gli altri componenti elettrici ed elettronici) vengono recuperati e gestiti secondo normativa da un impianto di smistamento dei RAEE;
- Fluidi come gli oli riduttori, circuiti idraulici dell'olio, sono segregati per la consegna ad impianti autorizzati di riciclaggio e per trattamenti specializzati;
- Il 33,3% dei polimeri sono riciclati. L'altro 66,6% (non riciclabili) sono per metà destinati a discarica e la restante in trattamenti di incenerimento.

- I restanti che comprendono principalmente le pale, rotor cover e navicella sono destinati a discarica.

In ottica di un'economia circolare, si evince che solo i materiali compositi costituenti sono destinati a trasporto a rifiuto (pale, rotor cover e navicella) ed in quanto tale si possono prendere in considerazione ipotetici scenari per la riduzione dell'impatto ambientale.

Tenendo conto che tutti i componenti delle turbine eoliche sono progettati per avere una durata pari o superiore alla turbina stessa e considerando la possibile esposizione del WTG a situazioni che differiscono dal normale operazione di progettazione, è necessario tenere conto che la durata prevista di un componente possa essere ridotta o disabilitata. A tal proposito si può evidenziare che mentre per la totalità dei materiali riciclabili è già definito un piano di dismissione sostenibile, per i materiali compositi si rende necessario ragionare in ottica di innovazione tecnologica:

- *Riduzione e Prevenzione:* implementando la vita utile dei componenti con l'implementazione di sistemi di monitoraggio che ne verifichino l'efficienza e riducano l'eventuale estensione del danno tramite riparazioni mirate in tempi accettabili;
- *Riuso* dei componenti nell'ambito di progetto d'arredo urbano (*Concepts for Reusing Composite Materials from Decommissioned Wind Turbine Blades in Affordable Housing (https://doi.org/10.3390/recycling3010003)*) o per la realizzazione di pensiline per biciclette (*Decommissioning of Onshore wind Turbines-Industry Guidance Document-Nov.2020*);
- *Riciclo e recupero* dei materiali compositi derivati dalle pale che prevedo una co-processazione delle fibre in vetro in un forno per cemento per la produzione dello stesso (*Nagle et al., 2020*) ed al contempo il recupero energetico dalla pirolisi della matrice organica costituente. (*End-of-Life alternatives for wind turbine blades: Sustainability Indices based on the UN sustainable development goals (https://doi.org/10.1016/j.resconrec.2021.105642)*)

Si intende inoltre sottolineare che nel progetto in esame le pale sono progettate in vetroresina (GlassFibersRP) che rispetto a quelle in fibre di carbonio, permettono uso di tecnologie con livello di maturità pari a 9 e con bassi costi di realizzazione come evidenziato nella figura sottostante.

Comparison of recycling and recovery technologies

	RECYCLING TECHNOLOGY	TYPE	MATURITY LEVEL (TECHNOLOGY READINESS LEVEL)	COST
GLASS FIBRE	Cement co-processing	Thermal	9	Low
	Mechanical grinding	Mechanical	9	Low
	High Voltage Pulse Fragmentation	Electro-mechanical	6	High investment and running costs
CARBON FIBRE	Pyrolysis & Micro-wave Pyrolysis	Thermal	Pyrolysis: 9 Microwave pyrolysis: 4/5	High investment and running costs
	Solvolysis	Chemical	5/6	High investment and running costs
	Fluidised Bed	Thermal	5/6	High investment and running costs

Fonte: Decommissioning of Onshore wind Turbines-Industry Guidance Document-Nov.2020.

È evidente quindi come il progetto eolico in esame sia perfettamente in linea con i principi dell'economia circolare. Inoltre, al termine della vita utile dell'impianto, ove non si ritenesse di procedere con un revamping, si dovrà procedere anche alla "Site restoration" ispirata ai principi atti ad impedire che durante la fase di smontaggio vi possano essere interazioni con le componenti ambientali più sensibili (acqua, suolo, vegetazione e fauna).

Di seguito, in analogia a quanto riportato nella SIA, viene quindi implementata una tabella riportante la valutazione della magnitudo degli impatti principali legati alla fase di "fine vita" e si rimanda al progetto ambientale SIA (VSSK6Y3_StudioFattibilitaAmbientale_34c) per una migliore comprensione della scala relativa al giudizio di impatto.

FINE VITA - DECOMMISIONIG					
Componenti Ambientali	**Sorgente di Impatto**	**Magnitudo Impatti**	**Misure di Mitigazione**	**Magnitudo Residua**	**Note**
Aria e Clima	- Smontaggio e trasporto pale in materiale composito - Smontaggio e trasporto componenti in acciaio - Demolizione parti in cls delle fondazioni delle turbine e delle opere di connessione - Dismissione cavidotti con sfilaggio cavi	**Bassa e temporanea**: gli impatti sulla componente atmosfera legati allo smontaggio delle turbine sono paragonabili ai medesimi che si generano in fase di cantiere per la realizzazione del parco eolico	-Utilizzo di mezzi operatori a basse emissioni di gas-serra - Razionalizzazione dei trasporti privilegiando destinazioni di trasporto limitrofe all'area dell'impianto - Razionalizzazione dei trasporti privilegiando percorsi di traffico asfaltati e bagnature per i tratti non asfaltati	Bassa	Tutti i materiali verranno destinati al riciclo nella massima misura possibile secondo l'evoluzione tecnologica del 2051
Acqua	- Smontaggio e trasporto pale in materiale composito - Smontaggio e trasporto componenti in acciaio - Demolizione parti in cls delle fondazioni delle turbine e delle opere di connessione - Dismissione cavidotti con sfilaggio cavi	Nessun impatto: - I WGT di progetto non ricadono nelle immediate vicinanze di corpi idrici superficiali o falde superficiali - i tracciati dei cavidotti non interferiscono con corsi o falde di acqua			
Suolo e Sottosuolo	- Smontaggio e trasporto pale in materiale composito - Smontaggio e trasporto componenti in acciaio - Demolizione parti in cls delle fondazioni delle turbine e delle opere di connessione - Dismissione cavidotti con sfilaggio cavi	Bassa e temporanea: durante la fase di dismissione si prevede la riduzione di tutte le aree occupate dall'impianto ed il ripristino alle condizioni originarie	A fine vita dell'impianto oltre al ripristino alle condizioni originali del suolo. In fase di smontaggio verranno adottate misure atte ad impedire la perdita di oli e carburanti dei mezzi operatori nelle aree di lavoro (come in fase di realizzazione dell'impianto)	Bassa	
Biodiversità	- Smontaggio e trasporto pale in materiale composito - Smontaggio e trasporto componenti in acciaio - Demolizione parti in cls delle fondazioni delle turbine e delle opere di connessione	Bassa e reversibile: come in fase di montaggio, per la fase di smontaggio e smistamento si avrà l'adeguamento della viabilità esistente di accesso, si potrebbe rendere necessaria la potatura di alcuni arbusti di macchia mediterranea	La potatura sarà effettuata con attrezzi manuali e non meccanici allo scopo di preservare per quanto possibile lo stato vegetativo della pianta e rendere tale operazione spontaneamente reversibile	Bassa	

	- Dismissione cavidotti con sfilaggio cavi				
Popolazione e Salute umana	- Smontaggio e trasporto pale in materiale composito - Smontaggio e trasporto componenti in acciaio - Demolizione parti in cls delle fondazioni delle turbine e delle opere di connessione - Dismissione cavidotti con sfilaggio cavi	Positiva e temporanea: vi sarà un aumento della forza lavoro necessaria ai lavori di dismissione con possibile coinvolgimento di maestranze locali e centri specializzati limitrofi			Tutti i materiali verranno destinati al riciclo nella massima misura possibile secondo l'evoluzione tecnologica del 2051
Beni materiali, Patrimonio culturale e Paesaggio	- Smontaggio e trasporto pale in materiale composito - Smontaggio e trasporto componenti in acciaio - Demolizione parti in cls delle fondazioni delle turbine e delle opere di connessione - Dismissione cavidotti con sfilaggio cavi	Bassa e temporanea: analogamente alla fase di realizzazione dell'impianto non si prevede necessario l'abbattimento di muretti a secco o opere patrimoniali in fase di dismissione	Qualora si ritenesse necessario l'abbattimenti di parti di muretto a secco, si procederà con la ricostruzione totale ed il riutilizzo del pietrame originario	Bassa	
Rumore	- Smontaggio e trasporto pale in materiale composito - Smontaggio e trasporto componenti in acciaio - Demolizione parti in cls delle fondazioni delle turbine e delle opere di connessione - Dismissione cavidotti con sfilaggio cavi	Bassa e temporanea: gli impatti sulla componente rumore legati allo smontaggio e alla demolizione sono paragonabili a quelli generati in fase di realizzazione dell'impianto. Le operazioni di dismissione saranno temporanee e limitate a circa 6 mesi		Bassa	

6.3 Restoration Ecology

RICHIESTAMiTE

Per le attività compensative di ripristino e restauro ambientale (in linea con le line guida della Restoration ecology) il proponente dovrà identificare, anche attraverso l'uso di documentazione fotografica (storica, ex-ante ed ex-post), necessità territoriali significative per gli habitat e le specie presenti, al di là dei semplici interventi di rivegetazione o rimboschimento.

RISCONTRO

Per contrastare gli effetti negativi prodotti dalla realizzazione di un' opera sugli ambienti naturali o seminaturali adiacenti, vi sono tre approcci fondamentali: la ***prevenzione*** (cercare di evitare che avvenga il danno), la ***mitigazione*** (minimizzare gli effetti negativi) e la ***compensazione***. Gli interventi di compensazione possono essere "on-site" nel caso in cui si vogliano migliorare le condizioni del luogo affetto dagli impatti negativi o "off-site" se vi è la creazione di nuovi habitat in aree esterne al sito disturbato.

Il Codice dell'Ambiente (D.lgs. 152/2006 art. 22, all.VII e ss.mm.ii.) prevede che per ridurre gli effetti negativi di tali opere, durante e/o dopo la realizzazione delle stesse, vengano attuate misure di mitigazione o compensazione compiute ad esempio attraverso la realizzazione di rimboschimenti con specie arboree-arbustive caratteristiche degli ambienti interessati dal passaggio dalle opere.

In riferimento alle linee guida pubblicate dalla SER (*The Society for Ecological Restoration International, Science and Policy Working Group, 2002*), il ripristino ecologico è presentato come metodo di conservazione attivo della biodiversità e caratterizzato da una serie di misure ed azioni poste in essere quando un'area di particolare pregio naturalistico è sottoposta a degli interventi che innescano dei processi naturali finalizzati alla riqualificazione e alla riabilitazione dell'area stessa e con essa agli ecosistemi in essa presenti.

Non esistendo tutt'oggi una definizione di Restoration Ecology univoca ed esaustiva, non è possibile affermare di conoscere gli ecosistemi naturali e le specie chiave originariamente presenti (che potrebbero oggi essere scomparse, avendo avuto l'ecosistema un evoluzione tale da non poterne definire le condizioni originarie) e dunque definirne gli interventi atti ad un restauro e ritorno alle condizioni originarie.

In tal senso per le attività compensative di ripristino e restauro ambientale, nell' ottica di proporre una forma di compensazione ambientale che rispondesse appieno ai *criteri di conservazione e* *rafforzamento della biodiversità*, il proponente ha pensato ad un **intervento di ampliamento del Bosco Tramezzone-Cerano** nel comune di San Pietro Vernotico. L'area di intervento rappresenta un importante nodo ecologico ambientale essendo incluso nelle aree protette ZSC "Bosco Tramezzone" (IT9140001) e Riserva Naturale Regionale Orientata Bosco di Cerano. Inoltre l'area d'intervento interessa le seguenti componenti botanico-vegetazionali "Boschi" e "Aree di Rispetto dei boschi" ai sensi del PPTR della Regione Puglia.

Una ulteriore proposta di compensazione ambientale è rappresentata dalla **creazione di "un'oasi della biodiversitα"**, attraverso la realizzazione di un apiario di idonee dimensioni unito alla **piantumazione di piante nettarifere coerenti con le essenze specifiche della zona territoriale**. Il tutto in collaborazione con una specializzata del settore, dotata di tecnologie capaci di sviluppare sistemi intelligenti di monitoraggio e diagnostica per la salute delle api. Il progetto avrà molteplici risvolti positivi dal punto di vista ambientale e territoriale, contribuendo in maniera specifica alla riduzione annuale di CO2 e rispondendo pienamente ai SDGs definiti dall'Organizzazione delle Nazioni Unite nell'agenda 2030 ("Quality education" "Decent Word and economic growth", "Industry, Innovation and Infrastructure", "Sustainable cities and communities", "Climate action", "Life on Land", "Partnerships for the goals").

Per documentazione tecnica specifica si rimanda a:

- *R.int.0 Relazione sintesi integrazioni*
- *R.int.2 - PIANO MONITORAGGIO FAUNA*
- *R.int.4 - AMPLIAMENTO BOSCO TRAMAZZONE*
- *R.int.3 - Comp. ambientale - Oasi della biodiversità*
- EGint1.3 - HABITAT E FAUNA.pdf

Tale documentazione è stata inviata dalla Società proponente come integrazione spontanea e volontaria con nota protocollo 30 Luglio 2021.

Il progetto di rimboschimento consente di instaurare processi e dinamiche naturali coerenti con le caratteristiche ambientali in cui è localizzato il sito di intervento. Gli interventi proposti rappresentano un primo passo per favorire il rafforzamento spontaneo da parte delle comunità vegetali tipiche dell'area di interesse.

La vegetazione inserita andrà a rafforzare gli attuali corridoi ecologici che contribuiranno a fornire quei servizi ecosistemici necessari alla qualità ambientale. Infatti, la scelta di inserire elementi arborei ed arbustivi della macchia garantisce aree rifugio per numerose specie faunistiche, e rappresenta una importante risorsa trofica per l'avifauna durante i mesi autunnali e invernali.

Numerose specie di Passeriformi migratori e svernanti, infatti, si alimentano dei frutti delle sclerofille sempreverdi e rappresentano i principali vettori di dispersione di queste piante nei contesti mediterranei.

Per quanto concerne gli aspetti faunistici, si ritiene in via preliminara di poter concludere che la realizzazione del progetto di mitigazione non può che sortire effetti positivi sulla biodiversità dell'area.

La scelta di concentrare gli interventi in prossimità della Riserva Naturale Regionale Orientata Bosco di Cerano offre l'opportunità di rafforzare la funzionalità ecologica della Riserva. Allo stesso tempo, la scelta di evitare la realizzazione di ripristino e riqualificazione vegetazionale nelle immediate vicinanze dell'impianto consente di evitare la creazione di nuove fonti di attrazione per la fauna e, di conseguenza, di aumentare le possibilità di impatti con gli aerogeneratori.

Di seguito si riporta una tabella esplicativa degli effetti attesi sulle componenti faunistiche del progetto analizzato.

Gruppo faunistico	Effetto	Dettagli
Mammiferi	Positivo	Aumento delle disponibilità trofiche e di siti di rifugio
Uccelli stanziali	Positivo	Aumento delle disponibilità trofiche in generale, creazione di nuovi habitat idonei alla riproduzione per specie della macchia ed ecotonali.
Uccelli migratori	Molto positivo	L' ampliameto del nucleo arboreo arbustivi in un contesto già naturalizzato può avere ricadute molto positive su specie migratrici che possono trovare nuove aree di sosta e rifugio durante il transito migratorio, costituendo dei veri e propri corridoi migratori.
Rettili	Positivo	Per tutte le specie si otterrà la creazione di nuovi habitat o l'incremento delle idoneità di quelli già presenti, incrementando fortemente la disponibilità di habitat trofici e di rifugio.
Anfibi	Molto positivo	La realizzazione del progetto porta alla creazione di nuovi siti di rifugio per specie di interesse conservazionistico dalle abitudini terricole.

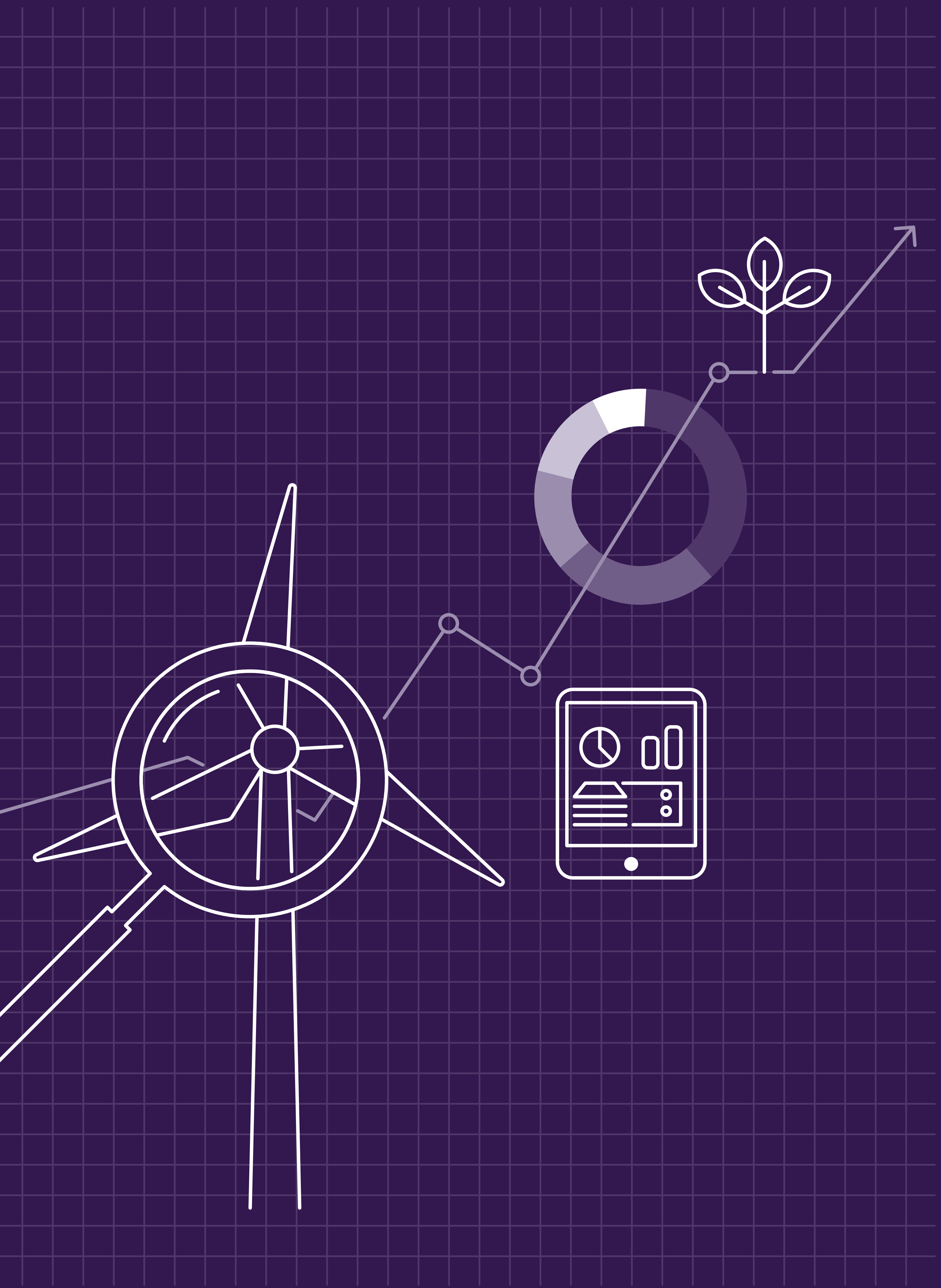
Analisi degli effetti del progetto sulla fauna presente nell'area indagata

Tutte le compensazioni ambientali e territoriali proposte, qualora ritenute idonee nell'ambito della Valutazione dell'Impatto Ambientale, e teso a migliorare le condizioni dell'ambiente interessato dal progetto eolico, sono commisurate al valore economico previsto dal 3% di cui al comma h) dell’art. 2 dell’allegato 2 al Decreto Ministeriale 10/09/2010.

A clean energy solution – from cradle to grave

Environmental Product Declaration
SG 8.0-167 DD

SIEMENS Gamesa
RENEWABLE ENERGY



Assessing the performance of a wind power plant

The environmental impact of wind power
The world today faces the challenge of meeting a growing demand for energy while reducing greenhouse gas emissions. One solution is to increase the contribution of renewable energy systems such as wind, sun, or biomass to the electricity mix. Siemens Gamesa Renewable Energy is pioneering this approach by offering an extensive wind turbine portfolio that includes the SG 8.0-167 DD turbine. Siemens Gamesa Renewable Energy has performed a Life Cycle Assessment (LCA) of an offshore wind power plant employing the SG 8.0-167 DD. The LCA evaluated the inputs, outputs, and potential environmental impacts that occur throughout the wind power plant lifecycle. It encompasses raw material extraction, materials processing, manufacturing, installation, operation and maintenance, and dismantling and end-of-life.

The results are presented in this Environmental Product Declaration (EPD) in order to communicate the impacts of our wind power plant to our stakeholders. All results are verified by internal reviews. The international ISO 14021 standard (environmental labels and declarations–self-declared environmental claims – Type II) is the basis for this EPD. The data presented has been derived from a full-scale LCA in accordance with ISO 14040.

Designed to deliver clean energy

Offshore wind power plant
This EPD is based on a full-scale LCA of an average European offshore wind power plant with 80 SG 8.0-167 DD turbines installed. It includes wind turbine components such as a nacelle, rotor, and tower, as well as the foundation, cables to grid, and substation.

The SG 8.0-167 DD is an upgrade in the Offshore Direct Drive platform. The upgrade allows the SG 8.0-167 DD to deliver up to 20% more energy output than its predecessor, the SWT-7.0-154.

The functional unit for this LCA is defined as 1 kWh of electricity delivered to the grid.

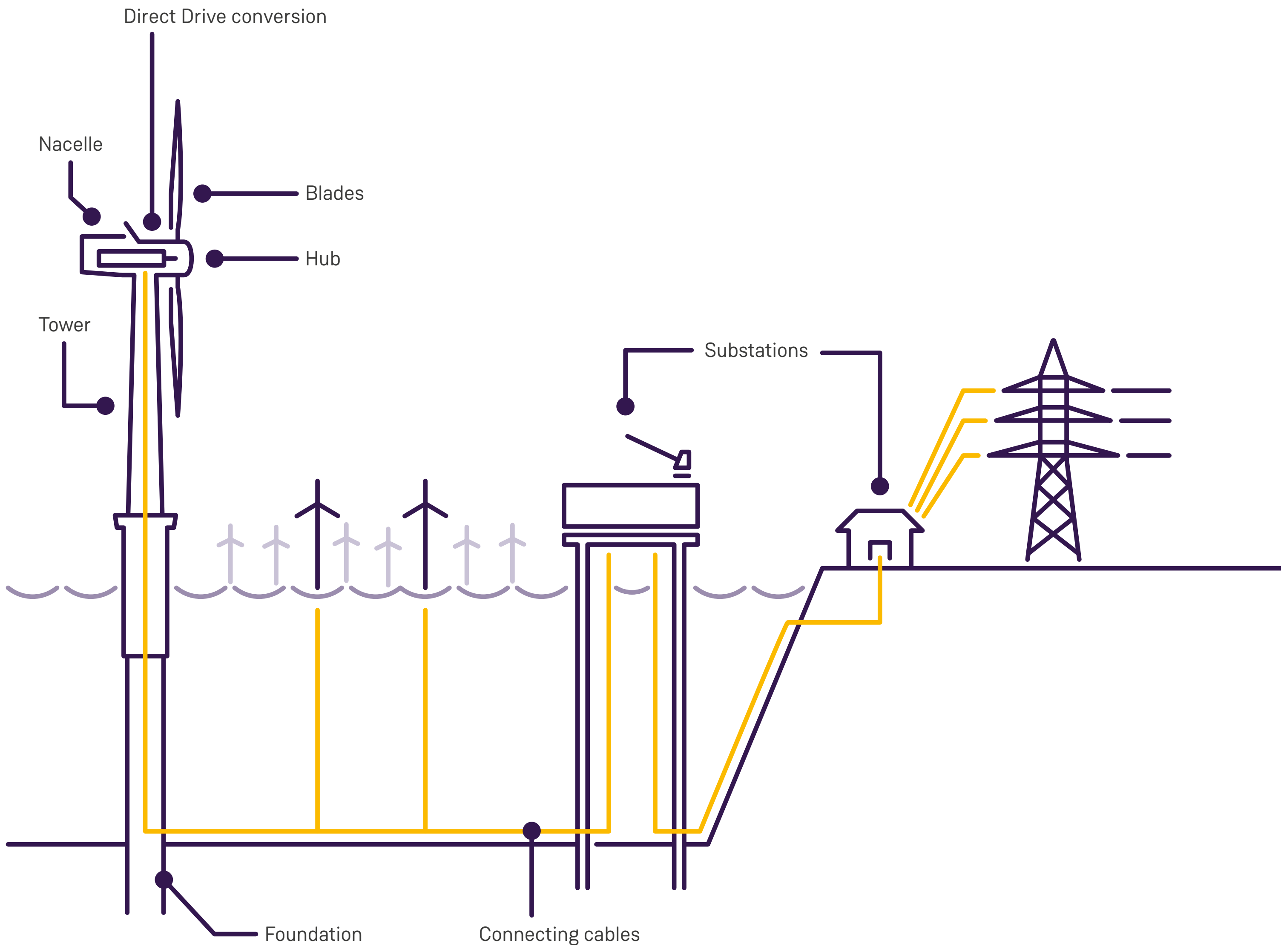
The identified average wind speed is relative to the turbine IEC classification.
Class I: 10 m/s for SG 8.0-167 DD.

Each wind power plant has specific site constraints that influence the choice of turbine, tower height, foundation size, and infrastructure.

Product and system description, including main components

Product and system description	Main characteristics
Turbine	SG 8.0-167 DD
Number of turbines in wind power plant	80
Expected lifetime	25 years
Expected average wind speed	10 m/s
Distance to shore/shore to grid	50 km/22 km
Annual energy production to grid per turbine (wake, availability and electrical losses substracted)	Approx. 34,000 MWh
Estimated energy production of the wind power plant in 25 years	68,035,000 MWh
Nacelle	8.0 MW DD (steel, iron, copper)
Blades	81 m (fiberglass, epoxy)
Tower	92 m (steel)
Foundation	925 t (steel)
Substations	12,700 t (steel, concrete)

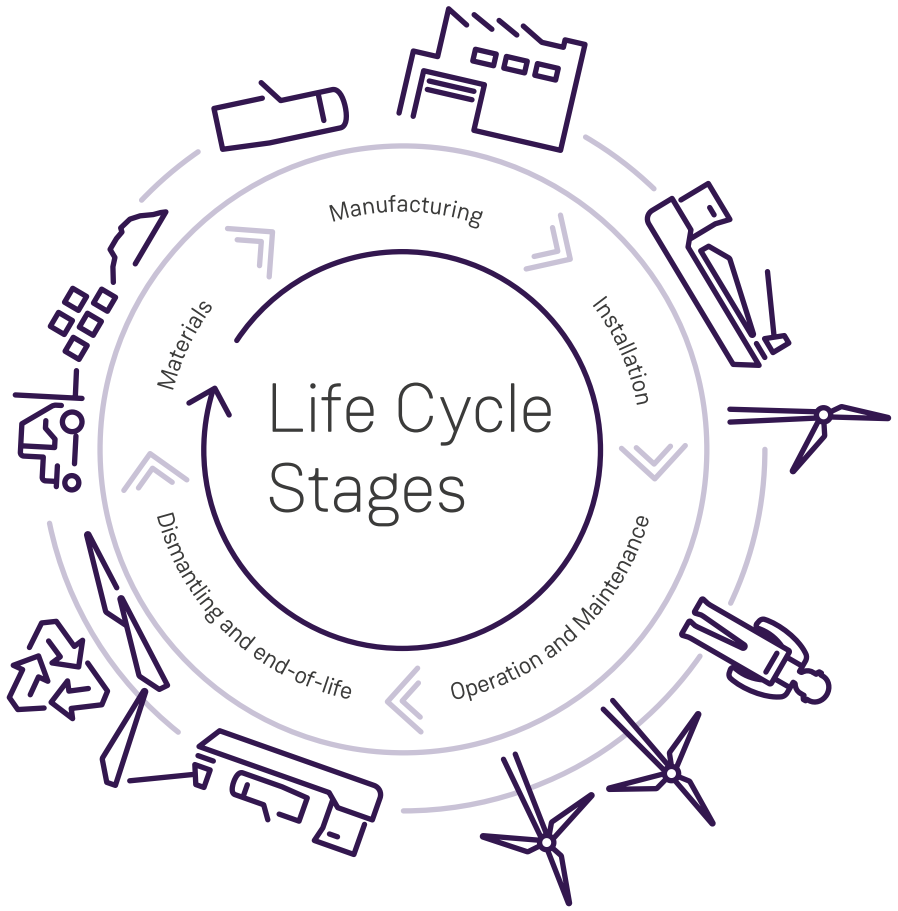
System boundaries for an offshore wind power plant



From cradle to grave

Life cycle of a wind power plant

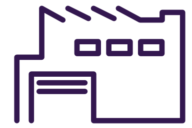
The lifecycle has been divided into five main stages: materials, manufacturing of the main parts, installation, operation and maintenance, dismantling, recycling, and disposal at the end-of-life. Relevant transport activities and energy consumption were included in each life cycle stage.



Materials

We identified the types and quantities of materials and energy that had to be extracted and consumed to produce the turbine components and the elements needed to connect the wind power plant to the grid, i. e. substations and connecting cables.

Manufacturing

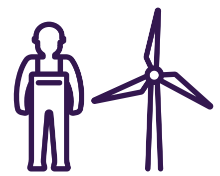


We collected data from Siemens Gamesa Renewable Energy's own production sites and from main suppliers. Consumption data for manufacturing as well as waste and subsequent treatment is based primarily on annual manufacturing data from European production sites. Transport of materials to the manufacturing site is included in the data.

Installation

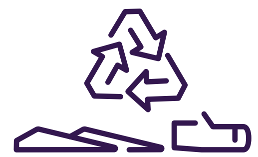
Components, auxiliary resources, and workers are transported to the site during this stage. On-site installation includes preparing the site, erecting the turbines, and connecting the turbines to the grid. These installation activities result in the consumption of resources and production of waste. Associated data has been collected from actual on-site installations.

Operation and Maintenance



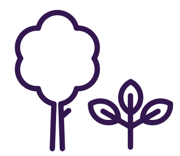
The structural design lifetime of an SG 8.0-167 DD turbine is designed to last 25 years. We collected actual site data, including manpower, materials, and energy required for service and maintenance over the turbine's lifetime. Wake, availability, and electrical losses have been included in our assessment to define a realistic estimate of annual energy production delivered to the grid.

Dismantling and end-of-life



At the wind power plant's end-of-life, the components will be disassembled and the materials transported and treated according to different waste handling methods. For the turbine components, we assumed that recycling would apply to all recyclable materials; for example, metals. Recycling leads to the recovery of materials, which subsequently reduces primary material extraction. The rest of the materials are either thermally treated or disposed of in landfills. The end-of-life stage described here represents the current status of waste management options in Northern Europe.

Other environmental impacts



Planning a new wind power plant includes assessing the environmental impact of the installation and operation phases to minimize negative impacts. Often these assessments focus on birds, marine wildlife and visual impacts. How a wind power plant impacts its surroundings varies depending on its location and is not included in our LCA study.

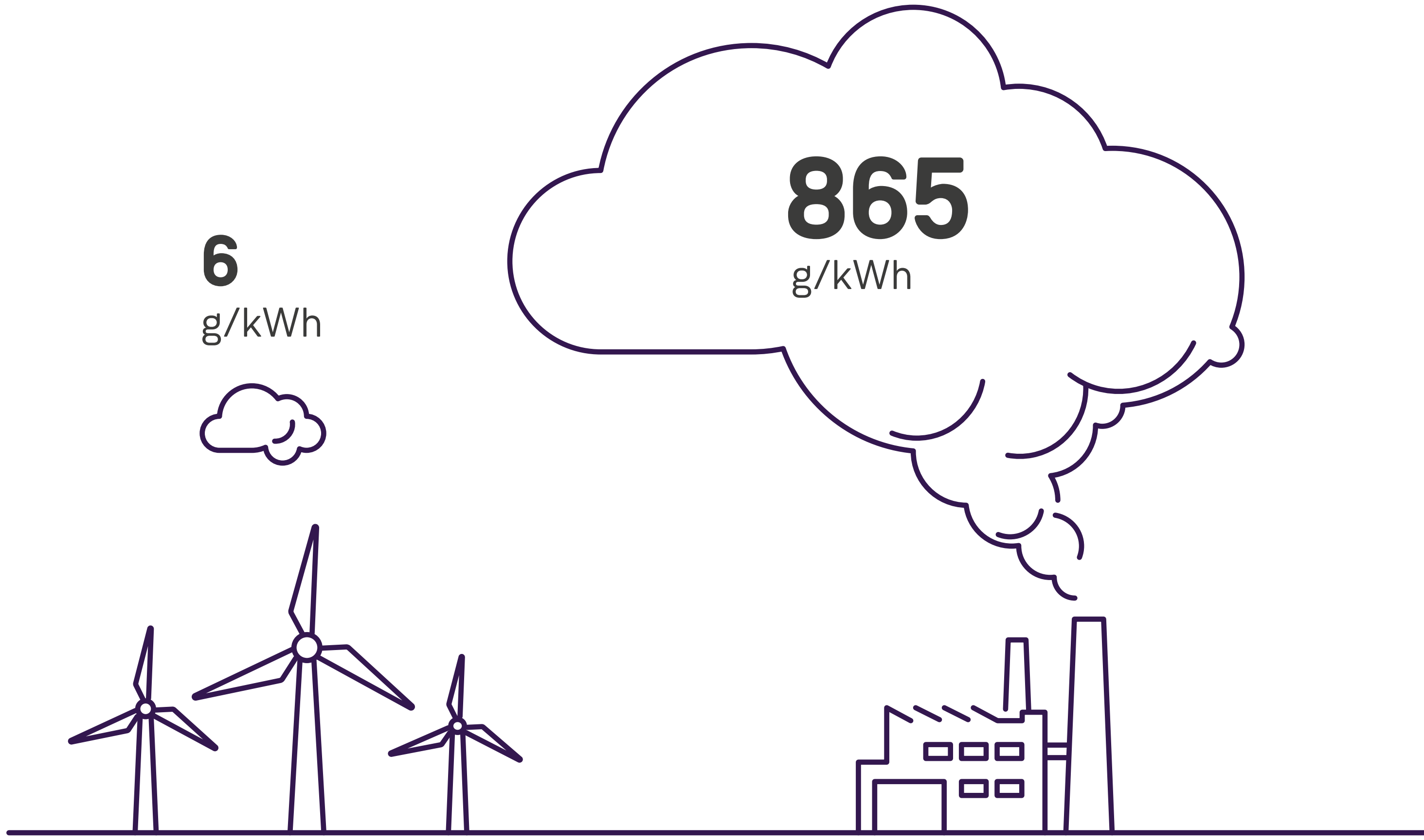
Environmental footprint

Low greenhouse gas emissions
Greenhouse gases such as CO_2 and methane contribute to global warming. Electricity produced by wind turbines contributes significantly less to global warming than electricity produced by fossil fuels. During its lifetime, the wind power plant emits less than 1% of the CO_2 emitted per kWh by an average power plant using fossil fuels.

7.4 months energy payback time
The energy payback time for the wind power plant in this assessment is less than 7.4 months. That is the length of time the wind power plant has to operate in order to produce as much energy as it will consume during its entire ifecycle.

Global warming is …
… an environmental impact caused by the increased concentration of greenhouse gases in the atmosphere. Each of these gases radiates different amounts of heat, which can be quantified in units of carbon called carbon dioxide-equivalent (CO_2 eq). (IPCC ref)

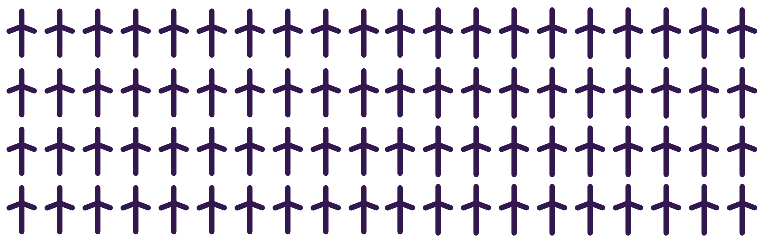
During its entire lifecycle the wind power plant produces 41 times more energy than it consumes.



CO_2 emissions from the wind power plant versus global fossil power production (IEA World Energy Outlook, 2012).

58,400,000 t
of CO_2 savings

1,667 km^2
forest area



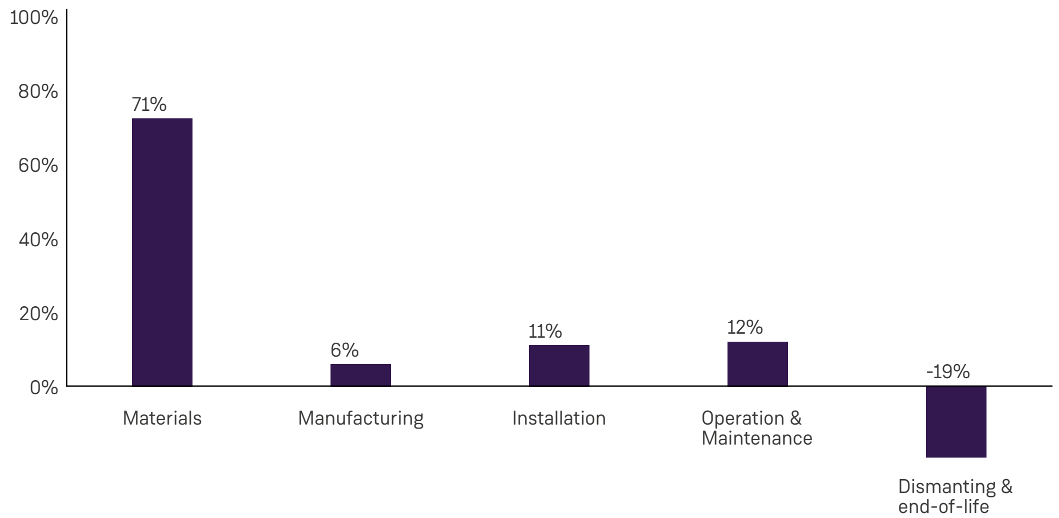
80 turbines, 25 years

During its estimated lifetime the wind power plant produces 68,035,000 MWh and saves 58,400,000 tonnes of CO_2, which is equal to the amount of CO_2 absorbed by a forest with an area of 1,667 km^2 over 25 years.

Every stage counts

Contributions to global warming
To examine how much each stage of the wind power plant's life cycle contributes to global warming, we assessed their specific CO_2 emissions (figure below).

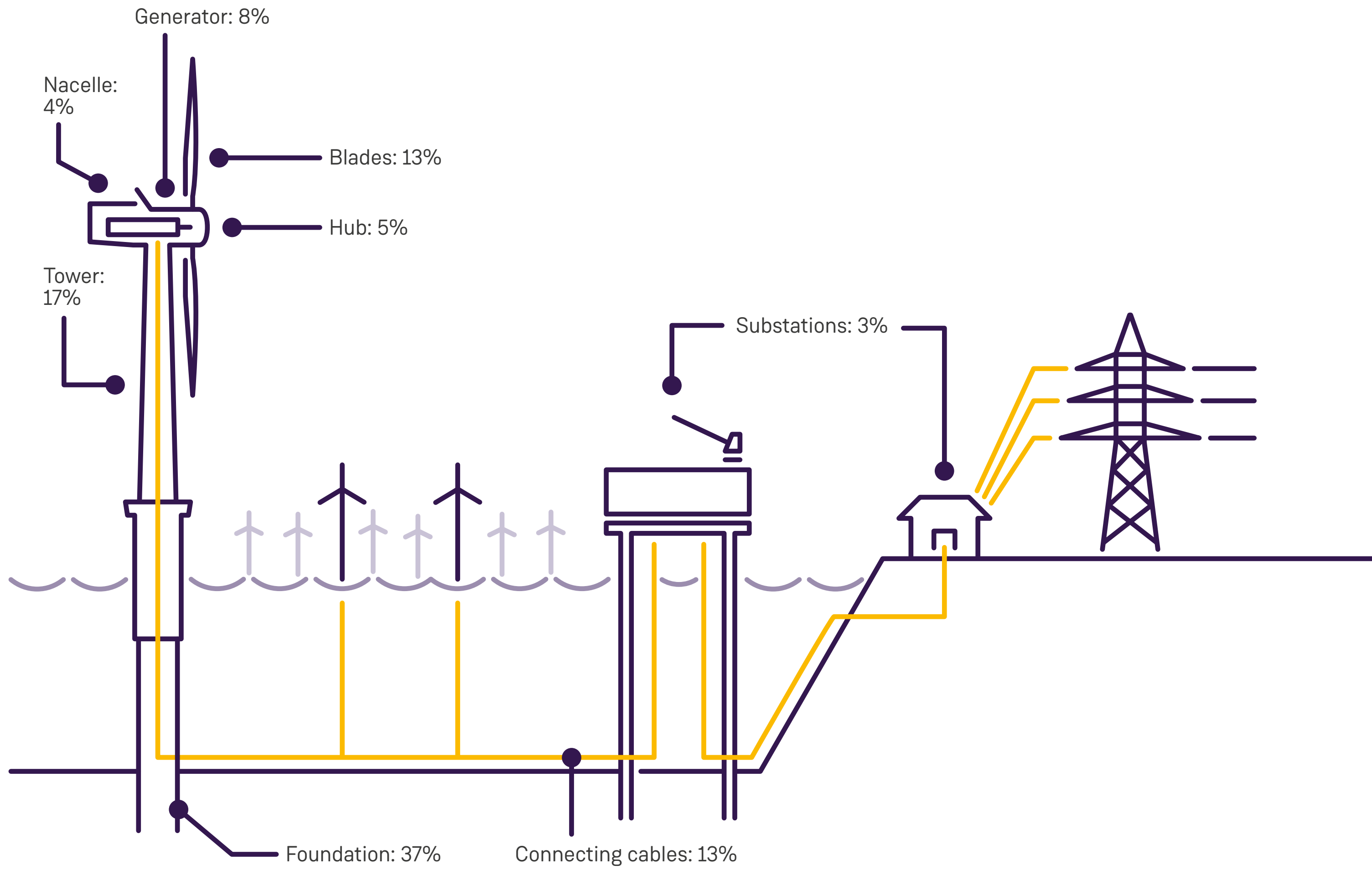
Percentage of global warming contribution from each life cycle stage (g CO_2 eq/kWh)



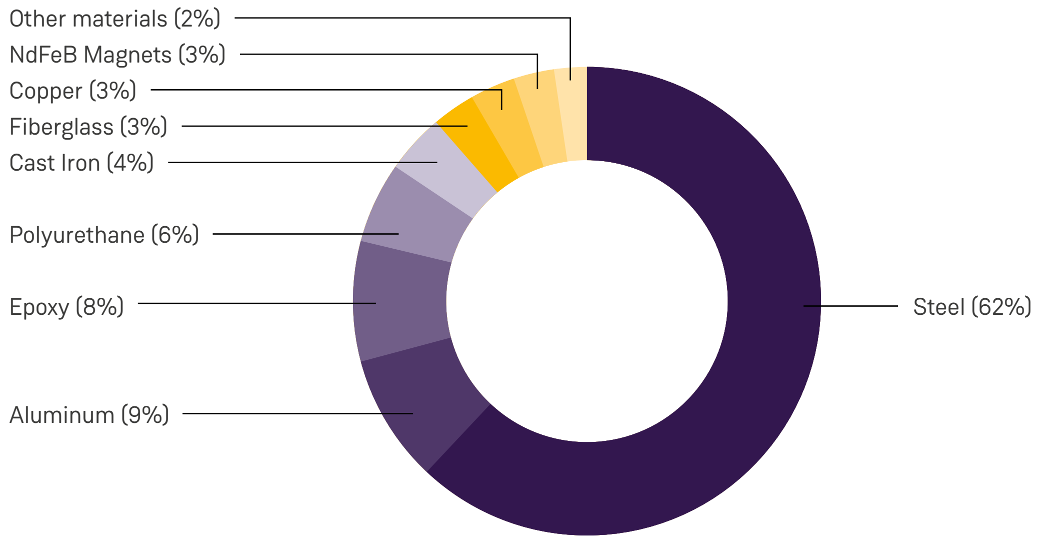
The main contributor to global warming is the materials stage (71%) because of the emissions during material extraction. The emissions related to manufacturing are minimal (6%), while those from installation and operation constitute approximately one-fourth of the total CO_2 impact (23%). Due to a high recyclability rate of the turbine materials, there is an offset to emissions at end-of-life.

Component and material group contribution to CO_2 eq emission
Each component and material group contributes to the total CO_2 eq emissions of the wind power plant. Among the components, the turbine's tower and foundation contribute more than 50%, followed by connecting cables, blades, and nacelle. In terms of material group contribution, steel has the highest impact on global warming, followed by aluminum and epoxy. The category with other materials consists of minerals, various plastics, chemicals, and wood.

Global warming contribution of main components in the wind power plant (CO_2 eq)



Global warming contribution per material group in the wind power plant (CO_2 eq)



Designing with a holistic view

Lowering the Levelized Cost of Energy
Siemens Gamesa Renewable Energy is one of the first companies showcasing its commitment to lowering the Levelized Cost of Energy (LCoE) for offshore wind power. In relation to this, we strive to continually improve wind turbine performance by including considerations for LCoE as well as environmental requirements in our design phase. We focus on increasing the annual energy output of the turbines and improving the material efficiency of the components.

Our improvement projects also focus on optimizing processes related to manufacturing, installation, operation and maintenance, dismantling and end-of-life. All these initiatives contribute to lowering the CO_2 eq per kWh of electricity delivered to the grid and reducing the LCoE. Hereafter, we describe some of our approaches to minimizing the environmental impact and LCoE throughout the life cycle of a wind power plant.

Optimizing magnets

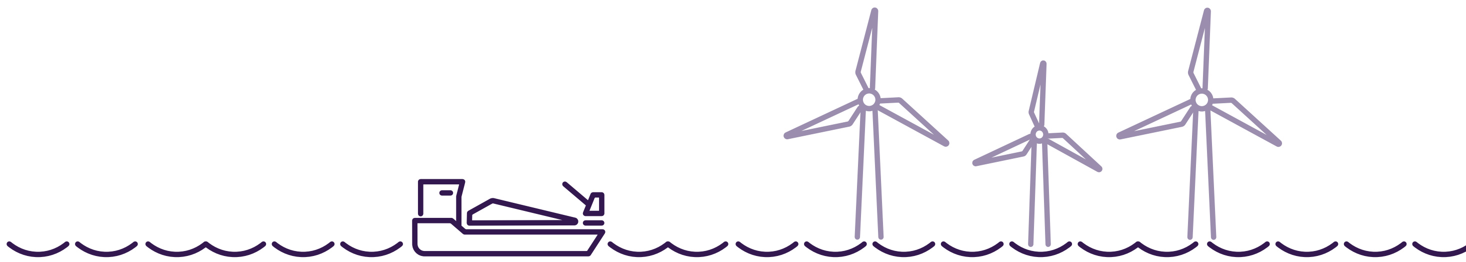
Siemens Gamesa Renewable Energy has, in collaboration with suppliers, improved the material use and manufacturing processes related to permanent magnets. After sintering, permanent magnets are conventionally ground from rectangular geometries into the desired shape needed for installation in the generator. This is a wasteful process because the grinding residue cannot be recycled 100%.

In collaboration with our suppliers, Siemens Gamesa Renewable Energy developed a new manufacturing method that allows the magnets to be shaped correctly from the start, which eliminates the extra grinding step. This involves pressing the magnet powder into new shapes that match the final product and therefore avoids unnecessary waste.

RoRo vessels for efficient installation

Further, Siemens Gamesa Renewable Energy works to improve the installation phase. The Roll-on-Roll-off (RoRo) vessel is a former container ship that has been rebuilt for its new purpose. Part of its new equipment is a large bow door that allows Ro-Ro access to the restructured cargo deck. The deck is covered by a telescopic roof to protect the nacelles from salty seawater spray during transportation.

Since the roof can be opened, the vessel's cargo can also be loaded via cranes at harbors without a Ro-Ro ramp. Due to the flexible layout of the deck, it can also carry up to nine wind tower sections per trip or three to four rotor blade sets. Savings of up to 15–20% in logistics are expected compared to existing transport methods.



Optimized maintenance with service operation vessels

To further optimize the operation and maintenance phase, Siemens Gamesa Renewable Energy launched the world's first Service Operation Vessels (SOVs) devoted to far-from-shore wind farms. The vessels are part floating hotels, part floating warehouses and when fully equipped, they are capable of remaining offshore at their respective wind farms for up to one month.

The vessels feature an innovative hydraulic walk-to-work gangway system that allows technicians to safely access wind turbines in extreme weather conditions. The specific improvements are illustrated below.

3 times higher availability at the wind farm compared to standard vessels

50% more operation days

20% less fuel consumption than projected

Disclaimer: Environmental improvements from RoRo vessels and SOVs have not been quantified in our LCA and are therefore not represented in our results or this EPD.

End-of-life is not really the end

Recycling turbine materials

When a turbine is dismantled, it has not necessarily reached its end-of-life. Turbines are often replaced by larger turbines, allowing the dismantled turbines to be refurbished and sold for installation elsewhere.

When disposing of wind turbines, recycling is the preferred solution. This not only prevents the materials from being sent to landfills, but also reduces the need for the extraction of primary materials.

Options for recycling or disposal

The metals in the wind power plant components are to a great extent recycled at their end-of-life. The blades, which are made of epoxy and fiberglass, may be shredded and incinerated. The burning of epoxy generates energy, which can be recovered. The residues from fiberglass incineration can be used in other secondary applications e.g. for cement production. Magnets from the direct drive turbines can be demagnetized, remagnetized and used or reused for new magnet production. Increasing recyclability of the turbine components is high on our agenda and we continually participate in projects to support development of more recycling options.

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Book 5139, Volume 60, Sheet BI-56858,
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SIEMENS Gamesa
RENEWABLE ENERGY

Electricity from a European onshore wind farm using SG 5.0-132 wind turbines

Environmental Product Declaration according to ISO 14025
PCR 2007:08 - Electricity, steam, and hot water generation & distribution - Version 4.0
The International EPD® System

Version	1.0
Publication date	2020-07-24
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Reg. Number	S-P-02156
Geographical validity	Europe

Contents

Acronyms and abbreviations

AEP	Annual Energy Production
BoM	Bill of Materials
B2B	Business to Business
B2C	Business to consumer
EPD	Environmental Product Declaration
GPI	General Programme Instructions
HSE	Health, Safety & Environment
IUCN	International Union for Conservation of Nature
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
LCoE	Levelized cost of energy
MW	Megawatt
WTG	Wind Turbine Generator

1. Introduction

1.1. Functional unit

This document represents the certified Environmental Product Declaration (EPD), of the electricity generated through an Onshore wind farm of SG 5.0-132 wind turbine generators, located in an European scenario and operating under high wind conditions (IEC I wind class).

Siemens Gamesa is dedicated to both the design and the manufacturing of its wind turbines as well as to the installation commissioning and maintenance 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:

Functional unit

1 kWh net of electricity generated through an onshore wind farm of Siemens Gamesa SG 5.0-132 wind turbine generators, located in a European scenario and operating under high wind conditions (IEC I), and thereafter distributed to a 132 kV European electrical grid.

A total reference flow of 3,704,084.783 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 8 SG 5.0-132 WTG under high 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 which optimizes the energy harvested. The baseline scenario includes 84 meters high towers.

Wind energy is the most reliable and effective renewable energy to meet the growing electricity demand[1], with the foreseeable depletion of the non-renewable traditional energy resources. Furthermore, it is a guarantee of competitiveness, because in most countries is responsible for the lowering price of the energy pool.

Although having common features with other renewable energy sources -avoids CO_2 emissions, it 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 electricity supply structure towards a truly sustainable energy future based on indigenous, non-polluting and competitive renewable technologies.

[1] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics

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 (Environdec) 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. Environdec, 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 2007:08. Electricity, steam, and hot water generation & distribution. Version 4.0
- General Programme Instructions for Environmental Product Declarations, Ver. 3.01;
- ISO 14025:2010 - Type III environmental declarations;
- ISO 14040:2006 and ISO 14044:2006 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 2007:08 - Electricity, steam, and hot water generation & distribution - Version 4.0:

- Information on the biodiversity protection;
- Information on land use and land cover classification in Europe;
- Information on environmental risks;
- Information on electromagnetic field generation;
- Information on the product noise;
- Information about the visual impact of the wind farm.

2. The company and the product

2.1. Siemens Gamesa Renewable Energy

Siemens Gamesa is a leading supplier of wind power solutions to customers all over the globe. A key player and innovative pioneer in the renewable energy sector, we have installed products and technology in more than 90 countries, with a total capacity base of over 89.5 GW installed globally and 23,000 employees.

Siemens Gamesa´s end-to-end value chain expertise encompasses onshore and offshore wind turbine design, manufacturing, installation as well as cutting-edge service solutions.

Onshore

Siemens Gamesa Onshore offers an extensive range of wind turbine technologies to cover all wind classes and site conditions around the world. Continuous innovation, a dedication to technological excellence and solutions adapted to customer needs are the pillars of our portfolio, setting the foundation for Siemens Gamesa as a benchmark technologist. This is backed by validated and recognized products, as well as by more than 35 years of experience and over 76.9 GW installed across the globe.

Offshore

Siemens Gamesa Offshore is the most experienced player in offshore wind; pioneering the industry when installing the world's first offshore wind power plant, Vindeby in Denmark, in 1991. Since then, we have successfully installed approximately 3,000 offshore wind turbines with a combined capacity of more than 11.5 GW. These turbines have been installed in Denmark, UK, Germany, Norway, Sweden, Finland, The Netherlands, China, and Taiwan.

Services

Siemens Gamesa has a proven track record of excellence in operation and maintenance. Leveraging scale and global reach, we offer a flexible service portfolio that can be tailored to our customers' diverse operating models. We also provide advanced diagnostics and digitalization capabilities, as well as customized offshore services.

Siemens Gamesa business management system, is certified according to the following international standards:

- ISO 14001:2015 - Environmental management systems;
- ISO 14006:2011 - Environmental management systems. Guidelines for incorporating eco-design:

Verified eco-designed wind turbines

- SG 114 - 2.1 MW
- SG 114 - 2.625 MW
- SG 126 - 2.625 MW
- SG 132 - 3.465 MW

- ISO 14064:2006 - Greenhouse gases;
- ISO 9001:2015 - Quality management systems;
- OHSAS 18001:2007 - Occupational health and safety management systems.

2.2. Product system description

The baseline system under study is an European onshore wind farm using SG 5.0-132 wind turbines with 84-meter towers. Since Siemens Gamesa started the LCA study, it was found interesting to extrapolate the results, 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 SG 5.0-132 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 farm is directly related to the environmental impact caused in the product distribution stage. The farther the wind farm is from the production centers, the more logistics needed.

To determine the geographical location of an average Siemens Gamesa 5.0 MW European wind farm, an analysis has been performed including the location of all the WTGs with a nominal power over 3.0 MW which have been sold by Siemens Gamesa during the last 5 years (2014-2018). Starting from that information, 6 different European countries have been considered, covering a 79.1% of the total installed power in Europe. The following table, contains the 6 selected locations including their relative representativeness within the LCA and the number of installed machines in the virtual site.

Country	Representativeness	Nº WTG
Sweden	26.4%	
UK	21.3%	
Ireland	17.1%	
Germany	17.0%	8
France	10.4%	
Denmark	7.8%	

Reference wind farm	Area
Sidensjö	Västernorrland
Lochluichart	Higland – Scotland
Mount Lucas	Offaly
Süderlügum	Schleswig-Holstein
Les Gourlus	Marne
Dostrup	Mariagerfjord - Nordjylland

Table 1: Country representativeness and reference locations selected for the European average wind farm

The countries analyzed are Sweden, UK, Ireland, Germany, France and Denmark. These 6 countries are considered representative of the European situation of Siemens Gamesa over 3.0 MW clients. For each of these 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 Europe has been calculated dividing the total installed power between the total number of windfarms, and rounding the number up to 8 wind turbines. Therefore, the installed power considered for the European average wind farm is set to 40 MW. When modelling the infrastructures shared by many wind turbines (i.e. transformer substation, internal wiring, connection infrastructure to the electrical network, road conditioning to allow access to machinery…), this average wind farm size of 40 MW installed has been used to reference all the values.

2.2.2. SG 5.0-132 Wind turbine

The Siemens Gamesa 4.X platform is one of the latest additions to the Siemens Gamesa product portfolio. Consisting of the SG 5.0-145 and the SG 5.0-132 wind turbines, two benchmark solutions in the market for sites with medium and high winds, Siemens Gamesa 4.X is the result of the operational experience accumulated by the company in the wind power industry.

Technical specifications

General details	
Rated power	5.0 MW
Wind class	IEC IA
Flexible Power rating	4.0-5.0 MW
Control	Pitch and variable speed
Standard operating temperature	Range from -20°C to 45°C (with de-rating) (1)

Rotor	
Diameter	132 m
Swept area	13,685 m²

Blades	
Length	64.5 m
Airfoils	Siemens Gamesa
Material	Fiberglass reinforced with epoxy resin

Tower	
Type	Multiple technologies available
Tower height	84 m and site-specific

Gearbox	
Type	3 stages

Generator	
Type	Doubly-fed induction machine
Voltage	690 V AC
Frequency	50 Hz/60 Hz
Protection class	IP 54
Power factor	0.9 CAP-0.9 IND throughout the power range (2)

Figure 1.- SG 5.0-132 WTG Technical specifications

Siemens Gamesa 4.X represents Siemens Gamesa's commitment to create value for our customers through the continuous development of new technologies that improve the performance, competitiveness and quality of our products. With a new state-of-the-art control system, enhanced blade aerodynamics and structural modularity, both the SG 5.0-145 and SG 5.0-132 offer our customers higher flexibility to adapt to sites with a wide range of wind conditions and logistics constraints.

Siemens Gamesa 4.X leverages the knowledge acquired through the development of our latest products and integrates innovative technologies to achieve higher efficiency and cost-effectiveness. It relies on proven concepts with extensive track record in the market, such as the combination of a three-stage gearbox (two planetary and one parallel) and a doubly-fed induction generator, which offer the higher levels of reliability. In addition to this, the inclusion of an optional premium converter allows us to comply with the most demanding grid connection requirements.

With over 30% increase in AEP over previous solutions from the Siemens Gamesa 3.X platform, the SG 5.0-145 and SG 5.0-132 models are a benchmark in their segment for LCoE and profitability. Designed for high wind sites, the SG 5.0-132 is boasting a 132-meter rotor, various tower options (84m or site specific) and increased nominal power of up to 5.0 MW, this turbine guarantees maximum efficiency at a reduced Levelized Cost of Energy.

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 m high towers.

2.2.3. Electricity transmission and distribution infrastructure

Once the wind is converted into electricity by the SG 5.0-132 wind turbine, 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, the environmental impacts associated with the construction and dismantling of the infrastructure needed to transport all the electricity generated by the WTGs, must be considered. The materials used to build these overhead lines, depend on the voltage level of the electricity being transported in each step, from the power generation until later consumption.

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

The WTG generates low voltage electricity (690 V). This voltage is increased in the transformer located inside the nacelle reaching medium voltage level to minimize electricity losses (30 kV). 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 Siemens Gamesa experiences in an European context, this value could be assumed to be 15 km average, which is the length of the line modeled for the LCA. The environmental impacts of building and dismantling this electricity transmission line have been taken from the Ecoinvent 3.5 (cut-off) LCI database. Ecoinvent estimates a technical service life for this kind of line of 30-40 years, over the windfarm technical life cycle.

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 2007:08 - Electricity, steam, and hot water generation & distribution - Version 4 for CPC 171, electrical energy.

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, biodiversity protection, 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 onshore wind farm using SG 5.0-132 wind turbines, located on an European scenario, operating under high wind conditions (IEC I) and thereafter distributed to an European 132 kV 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. These are the core module, the up-stream module and the 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 arrows represent the different transport of materials, parts or bigger components.

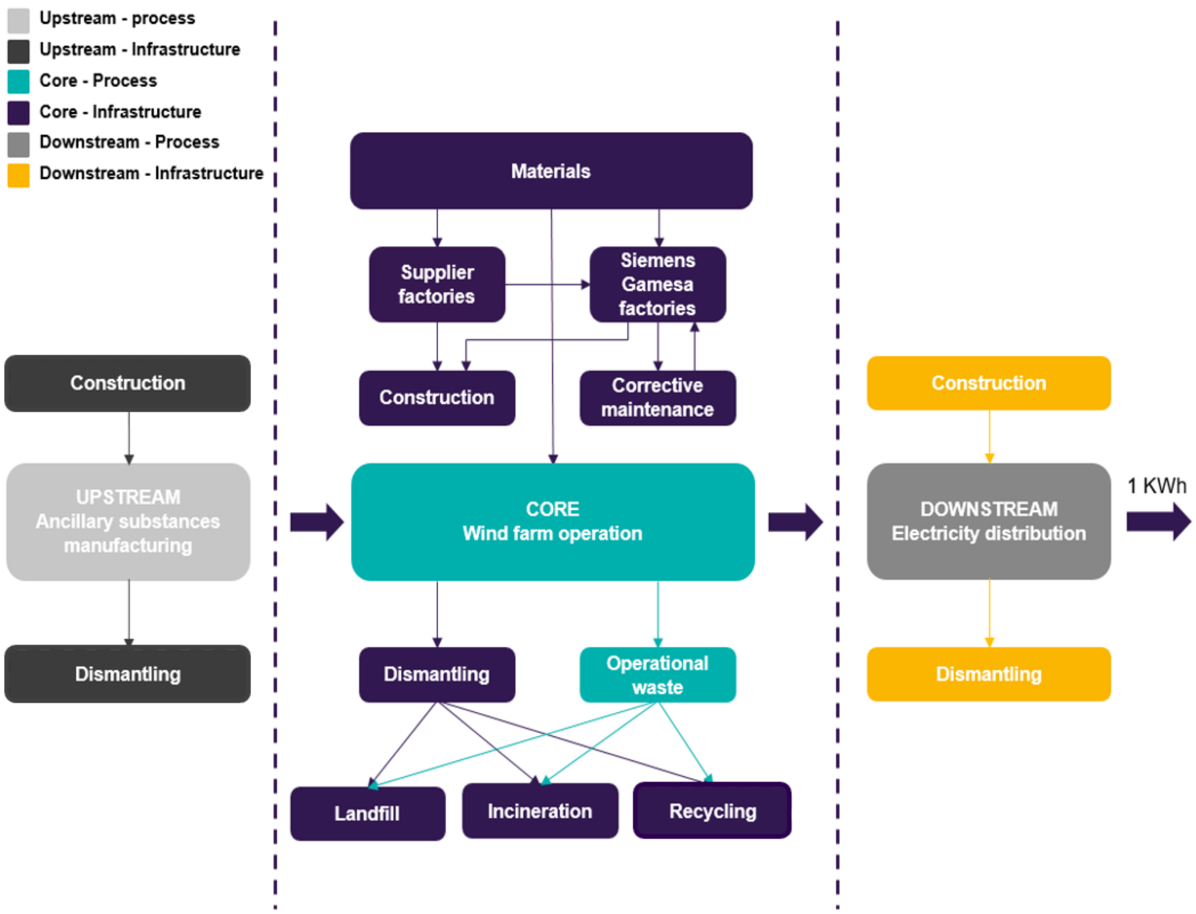

Figure 2: System boundaries

The data used to create the models of the life cycle phases described in the above diagram, have been obtained directly from Siemens Gamesa Renewable Energy 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 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, 99.54% of the total material flows of the system had been successfully included. The inflows that have been not included in the model, are related to small parts and pieces that are difficult to be inventoried (e.g. nuts, bolts, washers, small parts…). From previous Siemens Gamesa experiences, it is known that these parts do not have relevant environmental contribution in the results. 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 whole product system.

From these primary data, when creating the life cycle model of the analyzed system Ecoinvent 3.5 (cut-off) life cycle inventories database has been used. Ecoinvent is the most well-known 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 onshore wind farm using SG 5.0-132 wind turbines, 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 relevant PCR of the International EPD® System concerning this product category. In the manufacturing stage of the wind turbine, the annual environmental aspects of every production center were divided between the total units of components manufactured during that year in every specific location, in order to obtain the allocated impacts per wind turbine. Three different manufacturing centers required more detailed mass criteria to allocate their global impacts to every produced component, given the fact that they produce components not only for the SG 5.0-132 wind turbine but also for other machines. These centers were Valencia power converters at Benissanó (electrical cabinets), Aoiz (blade manufacturing) and Ágreda (Rotor/Nacelle 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 grease due to preventive maintenance, were obtained from the lubrication charts and from the maintenance manual of the SG 5.0-132 wind turbine. 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.

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.

3.2.2.1. 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 to the material consumption for the foundations and terrain adaptation.

For this EPD, Siemens Gamesa has calculated the environmental impacts arisen from the construction of a virtual 8 WTG wind farm model, as explained in section 2.2.1, and not from a single specific wind site. Siemens Gamesa holds reliable primary data on wind farm construction in a European context from two specific wind projects commissioned in 2019, which have been used as data sources. These are Ballestas windfarm (20 turbines) and El Valle windfarm (14 turbines), both located in Spain. These data have been adapted accordingly for the simulation of this virtual European 8 WTG wind farm.

Figure 3: Wind turbine generator assembly

Different items have been considered in the LCA model of the wind farm construction stage, such as the energy consumed by the machinery when building the foundations, the terrain adaptation and the WTG assembly, or the consumption of construction materials for the foundations and underground wiring networks. All the assets and materials needed for the construction of the on-site electrical substation, have also been included in the analysis.

3.2.2.2. Wind turbine generator manufacturing

On the other hand, Siemens Gamesa is responsible for the manufacturing and assembly 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 and assembly 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 1 year period (from January 2018 to December 2018, both included). In addition, the material breakdown of the WTGs has been extracted from the BoM of the turbine models actually designed during the year 2018.

In the case of an onshore SG 5.0-132 wind turbine delivered to any European location, the factories involved in the manufacturing of the machine are the ones collected in the following table. Primary data have been gathered for all of these manufacturing plants, which have been individually assessed for the purpose of the study.

Activity	Location	Owner
Assembly of converter and electrical cabinets	Benissanó - SPAIN	SIEMENS GAMESA
Nacelle & rotor assembly	Ágreda - SPAIN	SIEMENS GAMESA
Generator manufacturing	Reinosa - SPAIN	SIEMENS GAMESA
Gearbox manufacturing	Asteasu - SPAIN	SIEMENS GAMESA
Gearbox assembly	Lerma - SPAIN	SIEMENS GAMESA
Blades manufacturing	Aoiz - SPAIN	SIEMENS GAMESA
Hub manufacturing	Agurain - SPAIN	WEC
Tower manufacturing	Avilés - SPAIN	WINDAR

Table 2: Manufacturing plants included in the core infrastructure module

These facilities are responsible for the manufacturing and assembly of the main components of the SG 5.0-132 wind turbine, given an European client.

In addition to these processes, which are the ones related to the main components, in the following table 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 3.5 (cut-off) database.

Component	Supplier
Main shaft	Vitkovice
Main shaft bearings	Timken
Blade bearings	Rollix
Low speed coupling	Vitkovice
High speed coupling	KTR
Transformer	SGB Stakstrom
Yaw ring	Reducel
Hydraulic group	Glual
Nacelle / Rotor cover	Inpre
Crane system	Amenabar

Table 3: Main suppliers of the core infrastructure module components

Data on components directly purchased from suppliers and the distances traveled by these components to Siemens Gamesa manufacturing plants are real primary data, so that these distances closely match the reality of an European scenario. In addition, data on the distance traveled by the main components of the WTG to the wind farm, have been included considering the European average wind farm location explained in section 2.2.1.

3.2.2.3. Reinvestments

All the SG 5.0-132 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 5.0-132 turbines has been modeled in the LCA which supports this EPD. Data on failure rate statistics have been taken directly from internal studies made by Siemens Gamesa.

3.2.2.4. 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 Siemens Gamesa LCA experiences. 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	90 % 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 considered 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.

Figure 4: Blade manufacturing in Siemens Gamesa

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 functional unit. These are also primary data directly provided by the manufacturer.

3.2.4. Downstream

Lastly, 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. Accordingly, 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 Siemens 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 this electrical network have been obtained from the ecoinvent 3.5 (cut-off) database.

3.3. Eco-profile

In the following tables, the environmental performance of the SG 5.0-132 wind turbine from a life cycle perspective is shown, in the separated phases that were described above. The characterization factors for each of these impact categories have been extracted from the CML-IA environmental impact assessment methodology (version 4.8 - August 2016), the Intergovernmental Panel on Climate Change (IPCC 2013 – AR5), the AWARE method (WULCA recommendations on characterization model for water scarcity 2015, 2017), and the LOTOS-EUROS methodology as applied in the ReCiPe LCIA method 2008.

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:

Functional unit

1 kWh net of electricity generated through an onshore wind farm of Siemens Gamesa SG 5.0-132 wind turbine generators, located in a European scenario and operating under high wind conditions (IEC I), and thereafter distributed to a 132 kV European electrical grid.

3.3.1. Potential environmental impacts

Potential environmental impacts		Unit	Upstream	Core process	Core Infrastructure	Total generated	Downstream process	Downstream infrastructure	Total distributed
Global warming potential	Fossil	g CO_2 eq	2.01E-02	6.90E-02	4.98E+00	5.07E+00	1.12E-01	2.30E-01	**5.41E+00**
	Biogenic		1.57E-05	2.37E-05	6.12E-02	6.13E-02	1.35E-03	3.74E-04	**6.30E-02**
	Land use and transform.		2.31E-04	1.68E-05	7.03E-03	7.28E-03	1.60E-04	6.58E-04	**8.10E-03**
	TOTAL		2.03E-02	6.90E-02	5.05E+00	5.14E+00	1.13E-01	2.32E-01	**5.48E+00**
Photochemical oxidant formation potential		g NMVOC eq	1.63E-04	1.61E-04	3.15E-02	3.18E-02	7.00E-04	9.62E-04	**3.35E-02**
		g C_2H_4eq	6.20E-06	7.75E-06	2.10E-03	2.11E-03	4.65E-05	1.22E-04	**2.28E-03**
Acidification potential		g SO_2 eq	9.33E-05	1.58E-04	3.43E-02	3.45E-02	7.59E-04	1.62E-03	**3.69E-02**
Eutrophication potential		g PO_4^{3-} eq	2.11E-05	5.84E-05	2.95E-02	2.96E-02	6.51E-04	7.25E-04	**3.10E-02**
Particulate matter		g PM2.5 eq	1.02E-05	2.37E-05	5.57E-03	5.61E-03	1.23E-04	2.67E-04	**6.00E-03**
Abiotic depletion potential - Elements		g Sb eq	6.30E-08	5.04E-07	5.41E-04	5.41E-04	1.19E-05	4.54E-06	**5.58E-04**
Abiotic depletion potential – Fossil fuels		MJ, net calorific value	8.07E-04	5.55E-04	6.12E-02	6.25E-02	1.38E-03	2.18E-03	**6.61E-02**
Water scarcity potential		m^3 eq	3.51E-06	5.30E-06	1.52E-03	1.53E-03	3.37E-05	4.92E-05	**1.61E-03**

Table 5: Potential environmental impacts

3.3.2. Use of resources

Primary energy resources Renewable	Unit	Upstream	Core process	Core Infrastructure	Total generated	Downstream process	Downstream infrastructure	Total distributed
Used as energy carrier	MJ, net calorific value	1.20E-05	1.42E-05	6.41E-03	6.44E-03	1.42E-04	2.77E-04	**6.86E-03**
Used as raw materials	MJ, net calorific value	0.00E+00	0.00E+00	4.69E-05	4.69E-05	1.03E-06	0.00E+00	**4.79E-05**
TOTAL	MJ, net calorific value	1.20E-05	1.42E-05	6.46E-03	6.48E-03	1.43E-04	2.77E-04	**6.90E-03**

Table 6: Primary energy resources - Renewable

Primary energy resources Non-Renewable	Unit	Upstream	Core process	Core Infrastructure	Total generated	Downstream process	Downstream infrastructure	Total distributed
Used as energy carrier	MJ, net calorific value	4.08E-04	5.75E-04	6.60E-02	6.70E-02	1.47E-03	2.26E-03	**7.07E-02**
Used as raw materials	MJ, net calorific value	4.21E-04	0.00E+00	2.20E-03	2.62E-03	5.76E-05	2.38E-05	**2.70E-03**
TOTAL	MJ, net calorific value	8.29E-04	5.75E-04	6.82E-02	6.96E-02	1.53E-03	2.28E-03	**7.34E-02**

Table 7: Primary energy resources - Non-Renewable

Other resources	Unit	Upstream	Core process	Core Infrastructure	Total generated	Downstream process	Downstream infrastructure	Total distributed
Secondary material	Kg	0.00E+00	0.00E+00	4.14E-04	4.14E-04	9.10E-06	2.48E-05	**4.48E-04**
Renewable secondary fuels	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Non-renewable secondary fuels	MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Net use of fresh water	m3	1.25E-07	1.68E-07	5.05E-05	5.08E-05	1.12E-06	1.12E-06	**5.30E-05**

Table 8: Other resources

3.3.3. Waste production and output flows

Waste production	Unit	Upstream	Core process	Core Infrastructure	Total generated	Downstream process	Downstream infrastructure	Total distributed
Hazardous waste disposed	Kg	3.07E-10	1.31E-09	2.50E-05	2.50E-05	5.50E-07	2.68E-08	**2.56E-05**
Non-hazardous waste disposed	Kg	1.69E-06	1.57E-05	5.20E-03	5.22E-03	1.15E-04	4.60E-05	**5.38E-03**
Ash	Kg	2.49E-08	1.27E-07	1.52E-05	1.54E-05	3.39E-07	1.20E-06	**1.69E-05**
Inert waste	Kg	1.67E-06	1.56E-05	5.18E-03	5.20E-03	1.14E-04	4.48E-05	**5.36E-03**
Radioactive waste disposed	Kg	5.79E-09	3.46E-09	2.64E-07	2.73E-07	6.02E-09	3.91E-09	**2.83E-07**

Table 9: Waste production

Output flows	Unit	Upstream	Core process	Core Infrastructure	Total generated	Downstream process	Downstream infrastructure	Total distributed
Components for reuse	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Material for recycling	Kg	0.00E+00	0.00E+00	8.55E-04	8.55E-04	1.88E-05	4.72E-05	**9.21E-04**
Materials for energy recovery	Kg	0.00E+00	1.05E-05	0.00E+00	1.05E-05	2.30E-07	2.71E-07	**1.10E-05**

Table 10: Output flows

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.

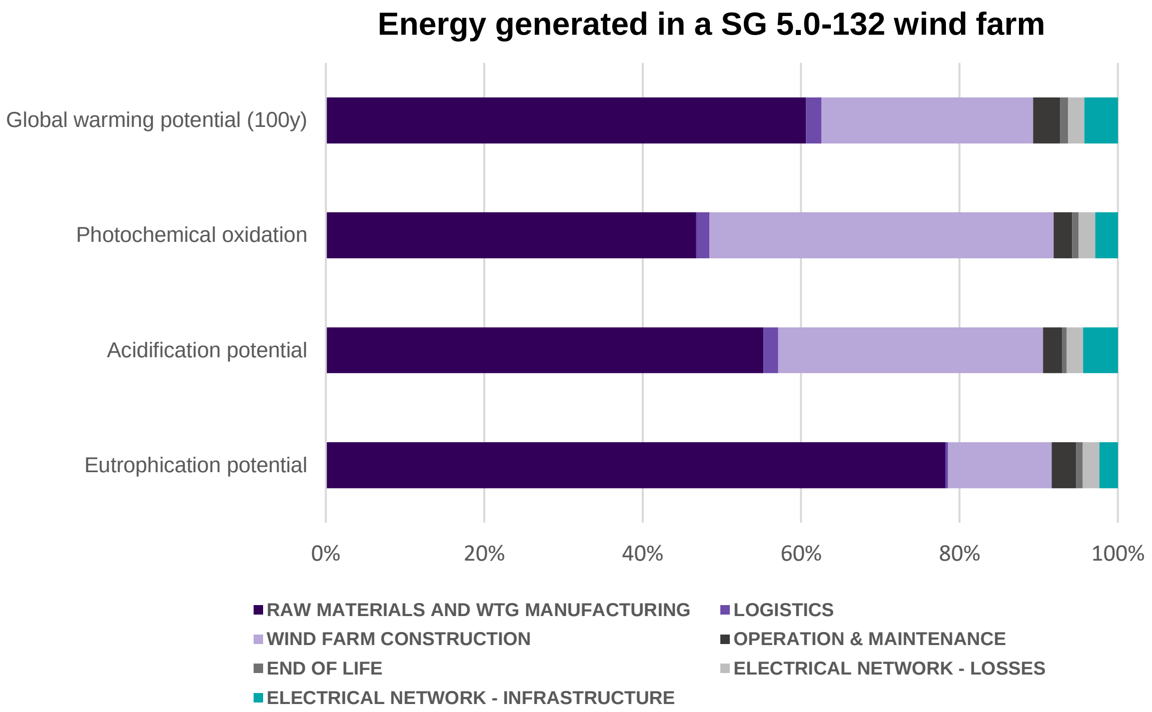

Figure 5: Environmental hot spots

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 89% of the total environmental impacts for these 4 impact categories.

From a life cycle point of view, these two stages are the main hot-spots of the energy generated in the SG 5.0-132 windfarm, and should be carefully designed in future projects.

Nearly 60% (in average for the 4 impact categories) of the environmental impacts of the energy generated and distributed by a SG 5.0-132 WTG are 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 electrical system.

Concerning the wind farm construction, this stage represents 29.2% of the impacts (in average). The most relevant environmental aspects for the construction stage are the machinery use and material consumption when building the foundations and adapting the terrain of the wind farm.

Finally, the rest of the modules such as 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 SG 5.0-132 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. Biodiversity protection

Siemens Gamesa products and services, use certain natural resources (water, fossil fuels and wind) to perform its activities, thereby interacting with, and potentially affecting, ecosystems, landscapes and species. This mainly happens across our operations over the product life cycle, for example:

- When we establish new facilities;
- When constructing our wind power plants.

Some impacts to biodiversity can include, for example:

- Potential land use changes by using vehicles and machinery to open up paths and remove vegetation;
- Prolonged human presence which temporarily affects the behavior of species of fauna in a generally reversible way;
- Potential species mortality due to collisions with our customers' wind turbines.

Despite these potential impacts on biodiversity, Siemens Gamesa wind projects are constructed in a sustainable way allowing a balanced coexistence, thus conserving and protecting natural assets, i.e. biodiversity and climate. This respect for biodiversity and ecosystems plays a leading role in the company's business strategy. There are different regulatory and voluntary instruments to achieve a positive net balance in relation to biodiversity and the environment, including:

- Company policies and procedures under the integrated management system;
- Full compliance with permits granted by environmental and conservation authorities at each region, which set out requirements to ensure the local environment's protection;
- Setting environmental and control plans and implementing management systems, the majority of which have been certified according to the ISO 14001 standard to prevent and control environmental risks;
- Fulfilling legislation on conducting environmental impact studies, which include analysis and prevention mechanisms that consider different alternatives and lay down corrective measures to avoid, mitigate or offset any possible damage.

As a general rule, protected areas and areas of high biodiversity value without protection are avoided during the design stage of new infrastructures. Potential environmental impacts are analyzed through a formal HSE aspects evaluation and by conducting environmental impact assessments beforehand, with measures to correct and minimize the impacts. In case that they cannot be completely mitigated, offsetting measures are taken.

The company 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 Siemens Gamesa's activities is permanently monitored to take the necessary measures to avoid endangering them.

4.2. Land use

As this EPD is not relative to one specific site in Europe, but to an average European Siemens Gamesa location, a specific land use analysis cannot be performed. Alternatively, a description on the land uses across Europe, has been performed.

The data source used for the land use and land cover classes information in Europe, are the maps published by the Copernicus Land Monitoring system. Copernicus, is a European system for monitoring the Earth. Data is collected by different sources, including Earth observation satellites and in-situ sensors. The data is processed and provides reliable and up-to-date information in six thematic areas: land, marine, atmosphere, climate change, emergency management and security.

4.2.1. Description of land cover classes across Europe

The following table shows the land cover classes across the area for which the study is representative. The surface is expressed in hectares. The bigger areas in Europe are occupied by non-irrigated arable lands as well as by coniferous and mixed forest, which will be the most common affected areas when a new wind farm is built.

Land cover classes	Surface (ha)	%
Urban fabric	21,587,189	4.1%
Other artificial areas	1,606,124	0.3%
Non-irrigated arable land	109,894,155	21.0%
Permanently irrigated arable land	4,695,274	0.9%
Pastures	41,045,873	7.9%
Other agricultural areas	55,442,269	10.6%
Broad-leaved forest	55,083,970	10.5%
Coniferous and mixed forest	104,911,554	20.1%
Other shrub and/or herbaceous areas	76,061,803	14.6%
Beaches, sands and rocks	23,490,231	4.5%
Burnt areas	223,000	0.0%
Wetlands	14,410,030	2.8%
Water bodies	13,962,613	2.7%
TOTAL	522,414,084	100.0%

Table 11: Land cover classes across Europe

4.2.2. Description of the activities on the occupied areas

The area of land occupied by artificial elements in a 8 wind turbine windfarm will be approximately of 174,240 m^2. This area will be mainly occupied by the following artificial elements during 20 years and 6 months, including the construction, operation and dismantling periods of the windfarm:

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

4.3. Environmental risks

Although the probability and severity of undesirable events is very low, the most representative environmental risk is the accidental oil spill. The environmental management system currently in place at Siemens 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, Siemens Gamesa is equipped with environmental anomaly detection, reporting and correction methods which are aimed at preventing this kind of events from being repeated. Significant spills are construed as spills that cause damage to the facility's external surroundings. Small spills are defined as spills with an actual consequence of moderate or lower corresponding to level 3 on a 1-5 scale.

A total of 308 small spills were recorded during 2018. There was just one significant spill in the reporting period, amounting to 1,700 liters of oil released from a pad-mounted transformer. All spills were reported and corrected in accordance with internal procedures. None of these spills required any exceptional corrective measures. When using the declared windfarm as reference, these spills happen less frenquent than once in three years.

4.4. Electromagnetic fields

The 2014/35/UE Directive regulates the electromagnetic compatibility of equipment. It aims to ensure the functioning of the internal market by requiring equipment to comply with an adequate level of electromagnetic compatibility. The directive makes a clear distinction between apparatus and fixed installations with regard to documentation of compliance with the protection requirements. The term "fixed installation", in the view of the European Commission, is a comprehensive term for electrical installations consisting of different types of apparatus and other devices that are combined permanently at an unchangeable location.

A formal conformity assessment of such installations is often difficult to perform and, in some cases, even impossible due to their size and complexity. In addition, fixed installations are often subject to constant change through which the formal conformity assessment of their undefined and changeable EMC conditions also appears to be problematic. Wind turbine is transported to its site of installation in separate parts and assembled on-site, erected and put into operation. It is operated exclusively at that location. According to these requirements, a wind turbine is a fixed installation according to the definition of terms in the EMC Directive.

For these reasons, the EMC Directive foregoes a formal conformity assessment and CE marking of fixed installations. However, it stipulates that such installations must be installed according to generally accepted rules of technology, and that the specifications for the intended use of the installed components have been observed. The measures for compliance with the essential requirements of the EMC Directive also has been documented in the technical file. In addition, the basic standard for the design of wind turbines, EN 61400-1, obligates to EMC assessment and to the respective measurements. According to the design risk assessment, there are not person exposed to electromagnetic radiation hazards in the wind turbine.

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 for the SG 5.0-132 wind turbine generator according to IEC 61400-14: 2005 and IEC 61400-11; 3rd Ed.; noise level is lower than 108.5 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 International EPD® System General Programme Instructions.

The EPD has been made in accordance with the General Programme Instructions for the International EPD® System, published by EPD International AB, and PCR 2007:08 - Electricity, steam, and hot water generation & distribution - Version 4.0, valid until 2024-03-16.

This certification is valid until 2025-07-24.

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. 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.

5.2.5. Ownership, liability and responsibility

The EPD owner has the sole ownership, liability and responsibility of the EPD.

5.2.6. EPD validity

An EPD should provide current information, and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com.

5.3. Programme and verification information

Programme and verification information	
EPD programme	The International EPD® System EPD International AB (Programme operator) Box 210 60, SE-100 31 Stockholm, Sweden www.environdec.com info@environdec.com
Registration Nº	S-P-02156
Publication date	2020-07-24
EPD validity	2025-07-24
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	☒ EPD verification ☐ EPD process certification
Third party verifier	Tecnalia R&I Certificación, S.L. Verifier: Maria Feced
Third party verifier accredited or approved by	ENAC. Accreditation no.125/C-PR283
Procedure for follow-up of data during EPD validity involves third-party verifier	☐ Yes ☒ No
LCA study developed by	IK Ingenieria
Reference Product Category Rules (PCR)	PCR 2007:08 - Electricity, steam and hot water generation and distribution - Version 4.0
PCR review conducted by	The Technical Committee of the International EPD® System. Full list of Technical Committee members available on www.environdec.com
PCR prepared by	Technical Committee of the International EPD® System PCR Moderators: Karin Lundmark – VATTENFALL AB karin.lundmark@vattenfall.com Sara McGowan – VATTENFALL AB sara.mcgowan@vattenfall.com

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6. Links and references

Additional information about Siemens Gamesa Renewable Energy:

www.siemensgamesa.com/en-int

Siemens Gamesa Renewable Energy sustainability commitment:

www.siemensgamesa.com/en-int/sustainability

Additional information about the International EPD® System:

www.environdec.com

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

http://www.ecoinvent.org