Hornsea Project Four:

Pro-rata Annex

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01	N/A	N/A	Document submitted at application.
02	9	Table 2	Number offshore export cable crossings corrected to 54 from 60
03	9	Table 3	Sandwave clearance volumes updated based on new MDS volumes

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Glossary

Term	Definition
Array cables (inter-array cables)	Cables which connect the wind turbines to each other and to the offshore substation(s).
Design Envelope	A description of the range of possible elements that make up the Hornsea Project Four design options under consideration, as set out in detail in the project description. This envelope is used to define Hornsea Project Four for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Export cables	Cables that transfer power from the offshore substation(s) or the converter station(s) to shore.
Export Cable Corridor (ECC)	A corridor of land/sea within which the electrical export cables will be located.
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current (AC), whereby the flow of electric charge periodically reverses direction.
HVAC booster station(s)	Offshore HVAC booster station(s) are required in HVAC transmission systems only; they are not required in HVDC transmission systems. If required for Hornsea Four, they would be located entirely offshore.
High Voltage Direct Current (HVDC)	High voltage direct current is the bulk transmission of electricity by direct current (DC), whereby the flow of electric charge is in one direction.
Hornsea Project Four offshore wind farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection

Term	Definition
	to the electricity transmission network. Hereafter referred to as Hornsea Four.
Interconnector cables	Cables that may be required to interconnect the offshore substations in order to provide redundancy in the case of cable failure elsewhere, or to connect to the offshore accommodation platforms in order to provide power for operation.
Maximum Design Scenario (MDS)	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.
Offshore accommodation platform(s)	Used to accommodate multiple O&M staff for a number of weeks at a time and to allow spares and tools to be stored within the array area.
Offshore substation(s)	One or more offshore substations to convert the power to higher voltages and/or to HVDC and transmit this power to shore.
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
Wind turbine generator	All the components of a wind turbine, including the tower, nacelle, and rotor.

Acronyms

Acronym	Definition
AfL	Agreement for Lease
DCO	Development Consent Order
GBS	Gravity Base Structure
OSS	Offshore substation
WTG	Wind turbine generator

Units

Unit	Definition
GW	Gigawatt (power)
kV	Kilovolt (electrical potential)
kW	Kilowatt (power)
KJ	Kilojoules (energy)
m	meters
km	kilometers

1 Introduction

1.1.1.1 Orsted Hornsea Project Four Limited, (hereafter the 'Applicant') is proposing to develop the Hornsea Project Four offshore wind farm (hereafter 'Hornsea Four'). Hornsea Four is located approximately 69 km offshore from coastline of the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network.

1.1.1.2 **Volume A4, Chapter 4: Project Description** presents a detailed description of the design of Hornsea Four, setting out design and components for both the onshore and offshore infrastructure, as well as the main activities associated with the construction, operation and maintenance, and decommissioning of Hornsea Four.

1.1.1.3 The Design Envelope approach has been used to include sufficient flexibility to accommodate further project refinement during detailed design, post consent. The final project design will depend on factors including ground conditions, wave and tidal conditions, project economics and procurement approach. **Volume A4, Chapter 4: Project Description** therefore sets out the maximum design parameters for Hornsea Four, which are encompassed within the Design Envelope.

1.1.1.4 This purpose of this annex is to present the pro-rata values for key parameters in the event that the maximum design scenario is not utilised to its full extent in the final project design. Table 1 to Table 4 outline the parameters that will change when an element of the project envelope, for example the number of cables, reduces in size.

2 Pro-Rata Tables

Table 1: Scour Protection Parameters for Different Foundation Types.

Parameter	WTG type foundation					Small OSS			Large OSS				
	Monopile	Mono-suction Bucket	Suction Caisson Jacket (WTG-type)	Piled Jacket (WTG-type)	GBS (WTG-type)	Suction Caisson Jacket (Small OSS)	Piled Jacket (Small OSS)	GBS (Box-type)	Suction Caisson Jacket (Large OSS)	Piled Jacket (Large OSS)	GBS (Large OSS)	Pontoon GBS - Type I	Pontoon GBS - Type II
Number of positions *	**180**	**180**	**180**	**180**	**110**	**6**	**6**	**6**	**3**	**3**	**3**	**3**	**3**
Anchor Drops (m^2)	288,000	288,000	288,000	288,000	88,000	0	0	0	0	0	0	0	0
Jack-Up Leg Placements (m^2)	367,200	367,200	367,200	367,200	0	12,240	12,240	12,240	6,120	6,120	6,120	6,120	6,120
Seabed Preparation Spoil (m^3)		764,538	924,240	618,706	685,794	343,470	201,720	227,070	337,500	188,160	393,660	278,460	261,360
Drilling Spoil (m^3)	127,235			47,501	0		9,236			4,618			
Total spoil volume (m^3)	**127,235**	**764,538**	**924,240**	**666,207**	**685,794**	**343,470**	**210,956**	**227,070**	**337,500**	**192,778**	**393,660**	**278,460**	**261,360**
Seabed Preparation / Disturbance (m^2)	-	443,342	511,379	349,883	411,321	73,926	44,376	49,686	71,148	40,368	82,668	59,148	55,488
Scour / Rock Protection Area (m^2)	763,407	282,743	508,938	162,860	504,540	39,584	7,735	150,000	30,159	5,311	120,000	54,360	54,612
Mudmats (m^2)					0		14,400			9,600			
Total Structure (m^2)	31,809	226,195	169,646	6,786	242,680	17,671	924	33,750	16,965	462	67,500	45,900	43,050
Total [Permanent Construction Seabed Area] (m^2) largest area of: "seabed	**795,216**	**508,938**	**678,584**	**349,883**	**747,220**	**73,926**	**44,376**	**183,750**	**71,148**	**40,368**	**187,500**	**81,900**	**76,800**

Parameter	WTG type foundation					Small OSS			Large OSS				
	Monopile	Mono-suction Bucket	Suction Caisson Jacket (WTG-type)	Piled Jacket (WTG-type)	GBS (WTG-type)	Suction Caisson Jacket (Small OSS)	Piled Jacket (Small OSS)	GBS (Box-type)	Suction Caisson Jacket (Large OSS)	Piled Jacket (Large OSS)	GBS (Large OSS)	Pontoon GBS - Type I	Pontoon GBS - Type II
Preparation /Disturbance" or "Structure" + "scour / rock protection"													
Scour / Rock Protection Volume [Material] (m^3)	1,526,814	565,487	1,017,876	325,720	1,009,080	79,168	15,471	300,000	60,319	10,622	240,000	108,720	109,224
Area and volume per position													
Seabed Preparation Spoil per position (m^3)	0	4,247	5,135	3,437	6,234	57,245	33,620	37,845	112,500	62,720	131,220	92,820	87,120
Drilling Spoil per position (m^3)	707	0	0	264	0	0	1,539	0	0	1,539	0	0	0
Total spoil volume per position (m^3)	**707**	**4,247**	**5,135**	**3,701**	**6,234**	**57,245**	**35,159**	**37,845**	**112,500**	**64,259**	**131,220**	**92,820**	**87,120**
Anchor Drops (m^2) per position	1,600	1,600	1,600	1,600	800	0	0	0	0	0	0	0	0
Jack-Up Leg Placements (m^2) per position	2,040	2,040	2,040	2,040	0	2,040	2,040	2,040	2,040	2,040	2,040	2,040	2,040
Seabed Preparation / Disturbance per position (m^2)	0	2,463	2,841	1,944	3,739	12,321	7,396	8,281	23,716	13,456	27,556	19,716	18,496
Scour / Rock Protection per position (m^2)	4,241	1,571	2,827	905	4,587	6,597	1,289	25,000	10,053	1,770	40,000	18,120	18,204

Parameter	WTG type foundation					Small OSS			Large OSS				
	Monopile	Mono-suction Bucket	Suction Caisson Jacket (WTG-type)	Piled Jacket (WTG-type)	GBS (WTG-type)	Suction Caisson Jacket (Small OSS)	Piled Jacket (Small OSS)	GBS (Box-type)	Suction Caisson Jacket (Large OSS)	Piled Jacket (Large OSS)	GBS (Large OSS)	Pontoon GBS - Type I	Pontoon GBS - Type II
Mudmats per position (m^2)	0	0	0	0	0	0	2,400	0	0	3,200	0	0	0
Structure per position (m^2)	177	1,257	942	38	2,206	2,945	154	5,625	5,655	154	22,500	15,300	14,350
Total [Permanent Construction Seabed Area] per position (m^2) largest area of: "seabed Preparation /Disturbance" or "Structure" + "scour / rock protection"	**4,418**	**2,827**	**3,770**	**1,944**	**6,793**	**12,321**	**7,396**	**30,625**	**23,716**	**13,456**	**62,500**	**27,300**	**25,600**
Scour / Rock Protection [Material] per position (m^3)	8,482	3,142	5,655	1,810	9,173	13,195	2,578	50,000	20,106	3,541	80,000	36,240	36,408
Depth of impact per position													
Drilling depth (m)	40	0	0	70	0	0	100	0	0	100	0	0	0
Seabed Preparation (m)	40	20	20	70	0	25	100	0	30	100	0	0	0
Seabed Preparation depth (m)	0	2	2	0	2	0	0	5	5	0	5	5	5

* Table Note: These numbers exclude accommodation platforms and the 3 HVAC booster stations.

Table 2: Volumes and Areas of Rock Protection Per Cable or Pipeline Crossing.

Parameter	Array Cables and Inter-Connection Cables	Offshore Export Cables
Number of crossings (no.)	32	54
Pre- and post-lay rock berm area (per crossing) (m^2)	6,400	6,400
Pre- and post-lay rock berm volume (per crossing) (m^3)	6,900	6,900
Pre- and post-lay rock berm area (total) (m^2)	204,000	382,000
Pre- and post-lay rock berm volume (total) (m^3)	221,000	414,000

Table 3: Boulder clearance and sandwave clearance parameters for Hornsea Four.

Parameter	Array cables	Offshore interconnector cables	Offshore export cables total
Number of cables	180	6	6
Length in km	600	90	654
Boulder clearance width per cable (m)	30	30	30
Sandwave clearance width per cable (m)*	40	40	40
Boulder Clearance - Seabed Disturbance (m^2)	18,000,000	2,700,000	19,500,000
Sand wave Clearance - Seabed Disturbance (m^2)*	18,000,000	2,700,000	19,500,000
Sandwave Clearance - Material Volumes (m^3)*	726,995	109,049	438,774
Pro rata per km			
Boulder Clearance - Seabed Disturbance (m^2) per km cable	30,000	30,000	29,817
Sand wave Clearance -- Seabed Disturbance (m^2) per km cable	30,000	30,000	29,817
Sandwave Clearance - Material Volumes (m^3) per km cable	1,212	1,222	671
Pro rata per cable			
Boulder Clearance - Seabed Disturbance (m^2) per cable	N.A.	N.A.	3,250,000

* Table Note: For calculation of sandwave clearance area and volume an average corridor width of 30 m has been used.

Table 4: Offshore operation and maintenance activities.

Cable remedial burial	Array cables	Offshore interconnector cables	Offshore export cables total
Length of cable estimated to require remedial burial over the lifetime of the wind farm (km)	42	7	14
Length of cable (per event) (m)	2,000	2,000	2,000
Width (per event) (m)	100	100	100
Seabed disturbance footprint (per event) (m^2)	200,000	200,000	200,000