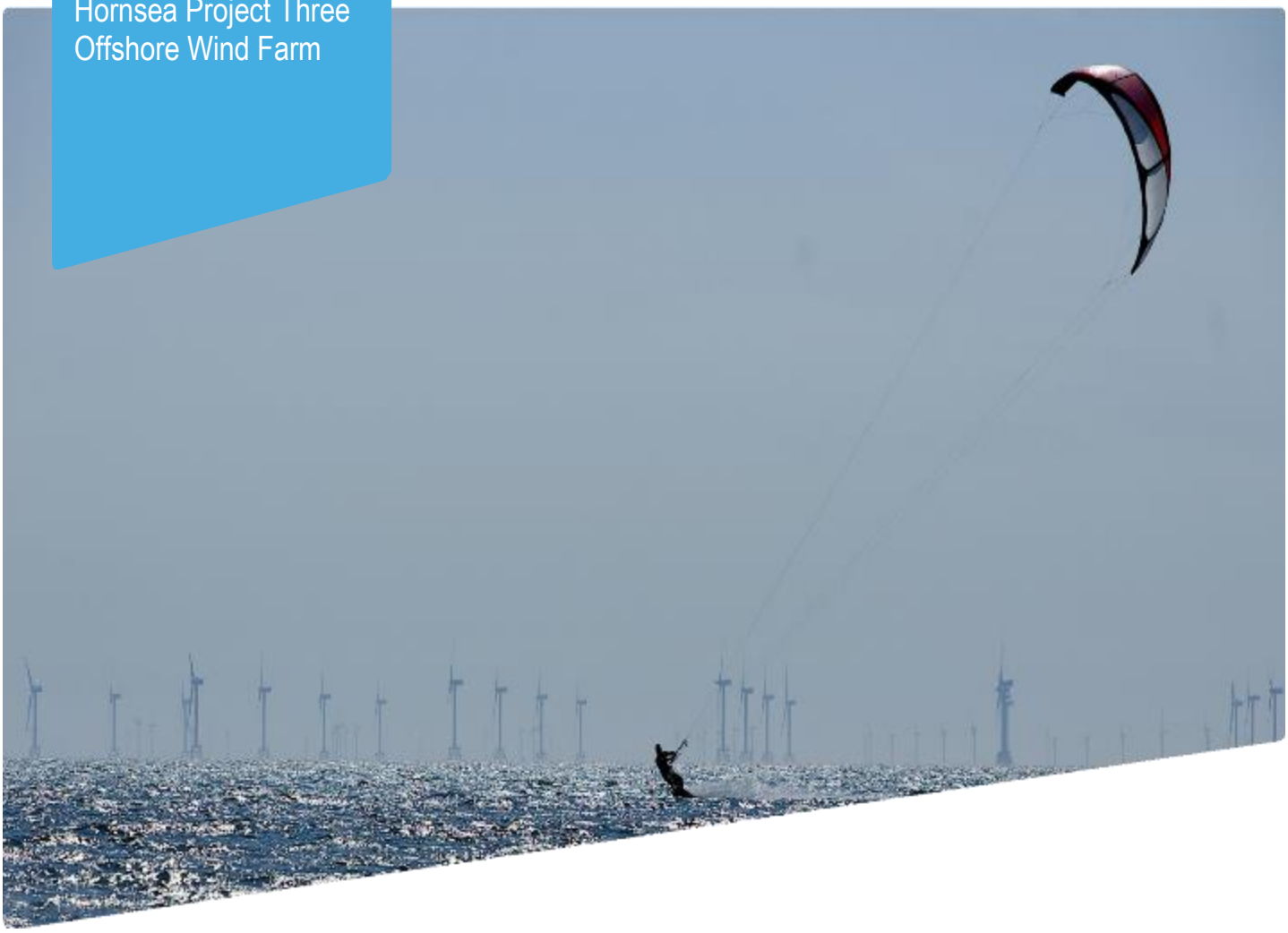
Hornsea Project Three
Offshore Wind Farm



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Appendix 19 to Deadline I submission – Vattenfall and Ørsted Circuit Crossing - EMF Information

Date: 7th November 2018

Hornsea 3
Offshore Wind Farm

Ørsted

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Front cover picture: Kite surfer near a UK offshore wind farm © Ørsted Hornsea Project Three (UK) Ltd., 2018.

National Grid has been engaged by Vattenfall and Ørsted to assess the EMF aspects of this case study, as described in this summary report. The projects as a whole and all other aspects of them remain the responsibility solely of Vattenfall and Ørsted.

Vattenfall and Ørsted Circuit Crossings- EMF Information

In response to local concerns, Ørsted and Vattenfall have jointly commissioned an independent study and resulting report which explores the 'worst case' electric and magnetic fields (EMFs) which may result where it is proposed the power cables from the large wind farms will cross.

Onshore, buried cables from offshore wind farms will necessarily cross other infrastructure, including other power cables. This summary report provides information on the electric and magnetic fields (EMFs) which could occur where power cable circuits cross, specifically assessing the crossing of Ørsted's Hornsea Project Three and Vattenfall's Norfolk Vanguard and Norfolk Boreas offshore wind farms, which are typical of the next generation of offshore wind projects in development by Vattenfall and Ørsted. It represents a conservative assessment of EMFs at such crossings, assessing the worse case parameters for this case study.

Summary of results

- The study found that the maximum calculated AC magnetic fields were 50.7 microtesla (µT) which is 14% of the UK exposure limit values; the maximum calculated DC magnetic fields were 60.8 µT which is less than 1% of the UK exposure limit.
- All of the cable crossing scenarios irrespective of whether DC or AC cable connections are used will be compliant with the UK exposure limits set to protect the health of members of the public against electric and magnetic field exposure.
- As the magnetic field is mainly dependant on cable rating, burial depth and phase separation, all cable crossings with similar or less onerous design parameters will also be compliant.

What are electric and magnetic fields and what policies and exposure limits apply?

EMFs are produced wherever electricity is used. Underground cables, irrespective of frequency, have an earthed metallic shield, which protects them from damage but also prevents electric fields escaping from the cable. Magnetic fields are not shielded in the same way as electric fields and will be produced outside the cables.

Electricity can be transmitted either via High Voltage Direct Current (HVDC) or High Voltage Alternating Current (HVAC) technology producing EMFs of the same frequency.

The UK has a carefully thought-out set of policies for managing EMFs, which includes numerical exposure limits to protect against established effects of EMFs. Public Health England (PHE), formerly the Health Protection Agency, (HPA) recommends limits for exposure to EMFs based on those from the International Commission on Non-Ionizing Radiation Protection (ICNIRP – 1994 & 1998)[1,2]. These guidelines are based on reviews of all the science regarding potential health effects of EMFs and provide limits for continuous public and occupational exposures. DC and AC EMFs have different effects on humans; therefore, each has a separate and distinct set of exposure limits to protect against exposure. PHE issued guidance on the application of exposure limits, which stated that the public exposure limit is 360 µT for 50 Hz AC magnetic fields, and 40,000 µT for DC magnetic fields[3]. In the UK the Earth's DC magnetic field measures around 50 µT, and the background AC magnetic field in a home ranges between 0.01- 0.2 µT.

More information on the science, exposure limits and policies can be found at www.emfs.info.

[1] https://www.icnirp.org/cms/upload/publications/ICNIRPstatic.pdf
[2] http://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf
[3] http://webarchive.nationalarchives.gov.uk/20140713082604/http://www.hpa.org.uk/Publications/Radiation/NPRBArchive/DocumentsOfTheNRPB/Absd1502/

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Where onshore wind farm circuits cross onshore, will these be compliant with exposure limits?

The electricity industry's policy is only to design and install equipment that is compliant with the relevant exposure limits. To ensure electricity Industry remain with the exposure limits the Government produced a Code of Practice on EMF compliance which sets out the approved calculation methodology for assessing compliance for new and existing electricity assets. This methodology takes account of maximum power flows and minimum burial depth to ensure that the calculated magnetic fields represent the maximum magnetic field that the electrical infrastructure could possibly produce.

There are multiple possibilities for cable crossing points i.e. AC or DC, which cables are on top, where they cross, the crossing angle – so the calculations in this summary report are the worst-case scenarios typical of the next generation of Vattenfall and Ørsted offshore wind projects in development in the UK.

If both cable routes that cross use the same power transmission technology, i.e. AC and AC or DC and DC, the fields can combine to add or subtract from one another. However, if different technologies are used, i.e. AC and DC, the magnetic fields do not interact with one another. In that scenario, the installations of the HVAC and HVDC cables can be considered separately.

These assessments represent the worst-case scenario for two crossing points, one where both transmission systems use HVAC technology and the other where both use HVDC technology. The parameters modelled are included in the tables below and are conservative as maximum rating, minimum burial depth and most acute crossing angle (45°) were taken and the most highly loaded circuits were located on top which produced the highest magnetic fields.

The calculated fields are shown below and are a small fraction of the AC and DC ICNIRP limits.

Cable design parameters

	2 x HVAC routes		2 x HVDC Routes	
	'On Top'	**'On Bottom'**	**'On Top'**	**'On Bottom'**
Number of circuits	6	12	2	4
Maximum load current per circuit	1620A	900A	2220A	1400A
Maximum circuit spacing at crossing	15.0m	10.0m	15.0m	10.0m
Spacing between phase centres	0.313m	0.25m	0.43m	0.25m
Cable formation in trench	Flat	Trefoil	Flat	Flat
Depth of burial, to circuit centres	0.8m	2.8m	0.8m	2.8m

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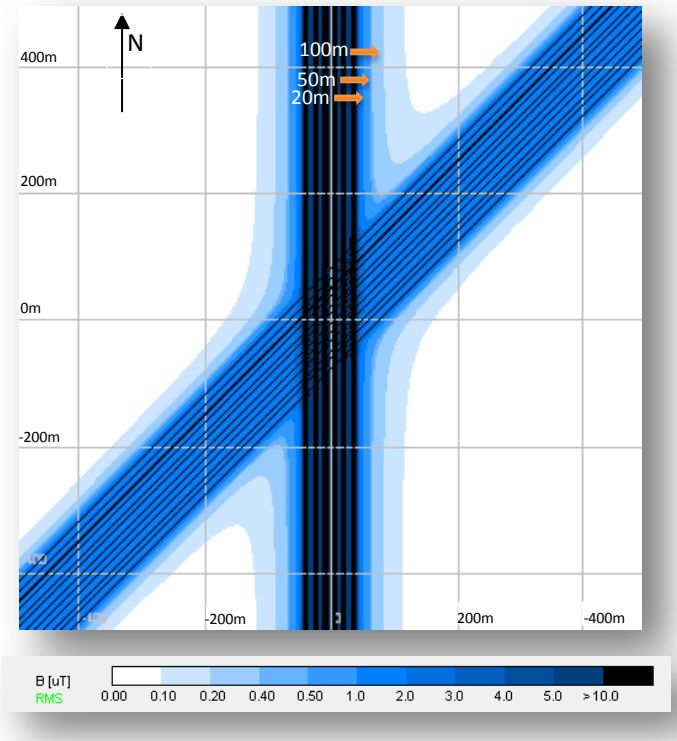
AC magnetic field calculations for HVAC cable crossings



Calculated worst-case AC Magnetic Fields

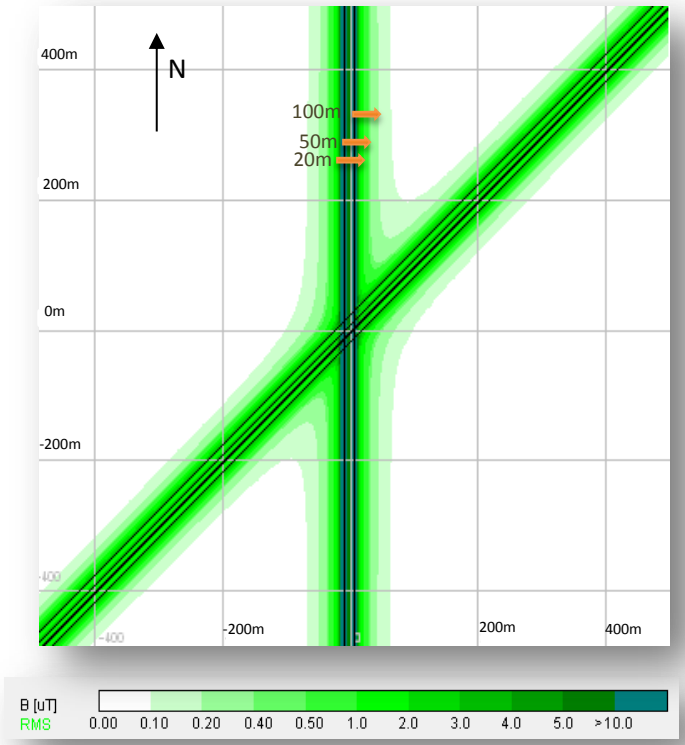
	Distance perpendicular from outer cable (m)			
	Peak	20m	50m	100m
Magnetic field (µT)	50.7	1.14	0.49	0.23
% ICNIRP exposure limit*	14%	<1%	<1%	<1%

*AC public exposure limit of 360µT

Worst-case calculated magnetic fields from AC circuits: The two cable routes modelled include 6 circuits running in a North-south direction with each circuit rated at 1620A; and 12 circuits which run underneath in a North East-South West direction with 900A rated circuits. Coloured bands represent magnetic field. Each square represents 200m distance. The orange arrows indicate the distance perpendicular from the outer cables that correspond to the table above.

The maximum calculated magnetic fields at various distances from the outer cable are included in the table and demonstrate that all AC magnetic fields are below the UK exposure limits

DC magnetic field calculations for HVDC cable crossings



Calculated worst-case DC Magnetic Fields

	Distance perpendicular from outer cable (m)			
	Peak	20m	50m	100m
Magnetic field (µT)	60.8	1.46	0.57	0.23
% ICNIRP exposure limit*	<1%	<1%	<1%	<1%

*DC public exposure limit 40,000µT

Worst-case calculated magnetic fields from DC circuits: The two cable routes modelled include 2 circuits running in a North-south direction with each circuit rated at 2220A; and 4 circuits which run underneath in a North East-South West direction with 1400A rated circuits. Coloured bands represent magnetic field. Each square represents 200m distance. The orange arrows indicate the distance perpendicular from the outer cables that correspond to the table above.

The maximum calculated magnetic fields at various distances from the outer cable are included in the table and demonstrate that all DC magnetic fields are below the UK exposure limits.

Where can I get further information?

More information is available from National Grid's website at www.emfs.info or from the EMF helpline on 0845 702 3270 or emfhelpline@nationalgrid.com.

Alternatively you can contact the Norfolk Vanguard project team directly on info@norfolkvanguard.co.uk or 01603 567995 or Hornsea Project Three on contact@hornsea-project-three.co.uk or 0800 0288 466.

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