Lower Thames Crossing

7.10 Health and Equalities Impact Assessment Appendix D – National Grid Electric and Magnetic Field Report

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Lower Thames Crossing

7.10 Health and Equalities Impact Assessment Appendix D – National Grid Electric and Magnetic Field Report

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1 Electric and Magnetic Fields

1.1 Introduction

1.1.1 This report provides an assessment of the likely significant environmental effects of Electric and Magnetic Fields (EMFs) associated with the modification of existing National Grid electricity infrastructure only to accommodate the proposed A122 Lower Thames Crossing (the Project). The proposed Project route interacts with some of the existing towers (pylons) which need to be moved or replaced. The operating conditions of the overhead lines will remain the same; the only changes will be to the height, location and number of towers present, and in some cases the conductor will be changed.

1.1.2 A total of five National Grid overhead line modifications are proposed to accommodate the Project at various locations:

a. ZB 275kV route, towers 32 to 34: A taller tower is being installed, replacing tower 33. The conductors will also be changed from twin Zebra to twin Totara

b. ZB 275kV route, towers 18 to 27: Eight existing towers are being dismantled and replaced with nine new towers on a slightly different alignment to allow A13 works. The conductors will again change from twin Zebra to twin Totara

c. YYJ 400kV route, towers 115 to 120: Four existing towers are being dismantled and replaced with four new towers on a different alignment to allow A13 works

d. ZJ 400kV route, towers 10 to 15 Three existing towers are being dismantled and replaced with five new towers on a slightly different alignment with the same conductor, twin Matthew

e. 4YN 400 kV route, towers 45 to 50. Four existing towers are being dismantled and replaced with four new towers on a slightly different alignment. One tower, 4YN049R will be raised significantly. The existing quad Zebra conductors will be replaced with twin Redwood conductors.

1.1.3 All equipment that generates, distributes or uses electricity produces EMFs. The UK power frequency is 50Hz, which is therefore the principal frequency of the EMFs produced; these are also known as Extremely Low Frequency (ELF) EMFs.

1.2 Electric fields

1.2.1 Electric fields depend on the operating voltage of the equipment producing them and are measured in V/m (volts per metre). The operating voltage of the equipment is a relatively constant value. Electric fields are shielded by most common building materials, trees and fences. Electric fields diminish rapidly with distance from the source.

1.3 Magnetic fields

1.3.1 Magnetic fields depend on the electrical currents flowing, which vary according to the electrical power requirement at any given time and are measured in µT (microteslas). They are not significantly shielded by most common building materials or trees. Magnetic fields diminish rapidly with distance from the source.

1.3.2 Magnetic fields are found in all areas where electricity is in use (e.g. offices and homes), arising from electric cabling and equipment in the area, typically ranging between 0.01µT and 0.2µT (Swanson and Renew, 1994).

2 Policy, legislation and guidance

2.1.1 All relevant policies and guidance, such as those contained within the Overarching National Policy Statement for Energy (EN-1) (Department of Energy and Climate Change (DECC), 2011a) and National Policy Statement for Electricity Networks Infrastructure (EN-5) (NPS EN-5) (DECC, 2011b) have been reviewed and applied to this assessment. These policies, guidance and legislation are explained and documented below.

2.1.2 NPS EN-5 (DECC, 2011b), gives clear guidance on the EMF requirements of all electricity infrastructure projects, stating:

'*Before granting consent to an overhead line application, the IPC should satisfy itself that the proposal is in accordance with the guidelines, considering the evidence provided by the applicant and any other relevant evidence*.' (paragraph 2.10.9), and:

'Where the applicant cannot demonstrate that the line will be compliant with the Electricity Safety, Quality and Continuity Regulations 2002, with the exposure guidelines as specified in the Code of Practice on compliance, and with the policy on phasing as specified in the Code of Practice on optimal phasing then the IPC should not grant consent.' (paragraph 2.10.11)

2.1.3 NPS EN-5 was consulted on in 2021. The draft consultation copy of NPS EN-5 contains no material changes to the requirements or assessment process that would impact this assessment.

2.1.4 Although only modifications to existing overhead lines are being made to accommodate the Project, the principles of compliance have been followed in the same way as for a new overhead line proposal.

2.1.5 A simplified route map for dealing with EMFs is provided in NPS EN-5 and is reproduced in Plate 2.1.

2.1.6 While there are no statutory regulations in the UK that limit the exposure of people to power-frequency EMFs, the responsibility for implementing appropriate measures to protect the public lies with the UK Government. In 2004, the Government adopted guidelines published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (ICNIRP, 1998) in line with the terms of the 1999 EU recommendation (Council of the European Union, 1999) on public exposure to EMFs. NPS EN-5 (DECC, 2011b) documents this policy.

2.1.7 The EMF guidelines documented in NPS EN-5 (DECC, 2011b) and their application are explained in 'Power Lines: Demonstrating Compliance with EMF Public Exposure Guidelines: A Voluntary Code of Practice (Code of Practice on compliance) published by the DECC (2012a). It is the electricity industry's policy to comply with Government guidelines on EMF, and this Code of Practice forms an integral part of this policy.

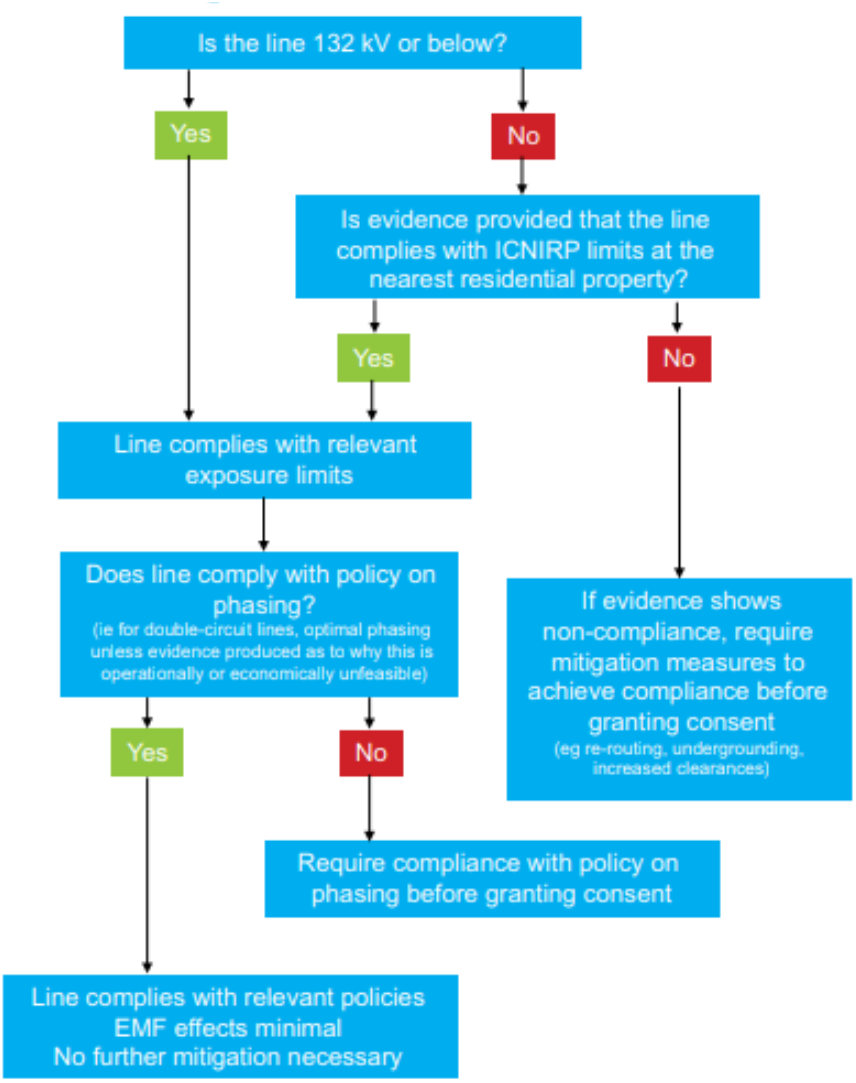
2.1.8 There is also a second Code of Practice, Optimum Phasing of High Voltage Double-Circuit Power Lines (DECC, 2012b), which sets out the principles for optimum phasing of overhead lines. This details the Government-supported precautionary measures recommended by the Stakeholder Advisory Group on Extremely Low Frequency Electric and Magnetic Fields (ELF EMFs) (2007) in its First Interim Assessment.

2.1.9 This assessment has been performed in line with the principles of both codes of practice (DECC, 2012a; 2012b).

2.1.10 There has been extensive research in an attempt to establish whether or not long-term exposure to fields at lower levels than the ICNIRP (1998) guidelines might be a cause of ill health in humans; this research has been extensively reviewed by bodies such as Public Heath England (National Radiological Protection Board, 2004) and the World Health Organization (World Health Organization, 2007). There is some evidence to suggest that high magnetic fields may be associated with an increased risk of one particular disease, childhood leukaemia. However, the weight of scientific evidence is against EMFs causing ill health in humans at levels below the ICNIRP (1998) guideline limits. The Government has addressed this uncertainty by adopting precautionary measures, set out in Code of Practice on optimum phasing (DECC, 2012b), which National Grid follows.

2.1.11 The exposure guidelines discussed above are set to protect against known or direct effects of EMF exposure. There are also ‘indirect’ effects that can occur as a result of exposure to EMFs which are not explicitly covered by the exposure guidelines. Examples of indirect effects are interference with active implantable medical devices (AIMDs) and microshocks (see Section 5.8). The potential impact of indirect effects has been assessed using the guidance provided in NPS EN-5 (DECC, 2011b) and the codes of practice.

Plate 2.1 Simplified route map for dealing with EMFs (reproduced from NPS EN-5)



3 Method

3.1 Study area

3.1.1 The assessment considers the EMFs produced by modifications to the existing electricity overhead lines necessary to accommodate the Project.

3.1.2 The existing overhead lines are fully compliant with Government policy and guidelines. The assessment study area includes areas where the existing overhead line would be modified, which would include replacing a tower, removing a tower or altering the conductor type. The study area includes all areas where the EMFs could potentially extend from the modified overhead lines.

3.2 Predicted EMF levels

3.2.1 EMFs have been assessed as per the conditions set out in the Code of Practice on Compliance (DECC, 2012a) and compared with UK Government exposure guideline limits. This assessment is a desk-based exercise using EMF calculation software including industry-standard modelling package EFC-400 and validated in-house modelling package EM2D.

3.2.2 The Code of Practice states that calculations should be performed at the maximum continuous rating of the conductors. Minimum conductor clearance, nominal voltage, 50Hz only and at 1m above ground, has been used for this assessment. The calculations for the proposed overhead line modifications were thus performed using worst-case conditions including minimum conductor clearances for overhead lines. The circuits are unlikely to operate at this maximum rating routinely, therefore resulting in lower typical magnetic fields on a day-to-day basis.

3.3 Assessment of effects

3.3.1 The proposed overhead line modifications would be assessed as having a significant effect if non-compliance with the EMF exposure limits was demonstrated, using the principles set out in Code of Practice on compliance (DECC, 2012a). Conversely, as specified in NPS EN-5 (DECC, 2011b), if the proposed overhead line modifications comply with the exposure limits and with the policy on phasing (DECC, 2012b), EMF effects are assessed as not significant and no mitigation would be necessary.

3.3.2 The UK Government's adopted guidelines are those of ICNIRP (1998), which are based on the avoidance of known adverse effects of exposure to EMFs at frequencies up to 300GHz, which includes the 50Hz EMFs associated with electricity transmission. These guidelines equate to a public exposure limit for uniform electric fields of 9.0kV/m and magnetic fields of 360µT. They apply particularly to residential properties.

3.4 Baseline environment

3.4.1 The existing overhead lines are located within a mixture of rural, urban and industrial areas, all of which accommodate other existing electrical assets. All equipment that generates, distributes or uses electricity produces EMFs. The UK power frequency is 50Hz which is the principal frequency of the EMFs produced.

3.4.2 As well as manmade sources of EMFs, such as the electricity system, they can also be produced naturally and have been present since the beginning of time. The earth's magnetic field, which is caused mainly by currents circulating in the outer layer of the earth's core, is roughly 50µT in the UK. This field may be distorted locally by ferrous minerals or by steelwork such as in buildings. At the earth's surface there is also a natural electric field, created by electric charges high up in the ionosphere, of about 100V/m in fine weather.

3.4.3 As detailed earlier in the chapter, the earth's natural fields are static, and the power system produces alternating fields. In homes in the UK that are not close to high-voltage overhead lines or underground cables, the average 'background' power-frequency magnetic field (the field existing over the whole volume of the house) ranges typically from 0.01–0.2µT with an average of approximately 0.05µT, normally arising from currents in the low voltage distribution circuits that supply electricity to homes (Swanson and Renew, 1994). The highest magnetic fields to which most people are exposed arise close to domestic appliances that incorporate motors and transformers. For example, close to the surface, fields can be 2,000µT for electric razors and hair dryers, 800µT for vacuum cleaners, and 50µT for some TVs and washing machines. The electric field in most homes is in the range 1-20V/m, rising to a few hundred V/m close to appliances (Swanson and Renew, 1994).

3.4.4 Given this report is assessing the impacts of modifying the existing overhead lines in the area, it is important to note that the overhead lines are already *in situ* and producing EMFs. The EMFs produced by each of the different routes will depend on the voltage, conductor type and bundle, clearance of the conductors above ground and the current. These proposed modifications will only affect the clearance of the conductors and in some cases the type of conductor. All the other factors would remain the same.

3.4.5 EMFs have been assessed as per the conditions set out in the Code of Practice on compliance (DECC, 2012a) and compared with UK Government exposure guideline levels to ensure the proposed modifications continue to comply with these requirements. This assessment is a desk-based exercise using validated EMF calculation software.

4 Assessment of EMF exposure against government policy

4.1 Introduction

4.1.1 Each of the overhead lines will produce EMFs when in operation, which vary depending on the design or type of equipment.

4.2 Operational effects

4.2.1 Energised high voltage overhead transmission lines are a source of both electric and magnetic fields. The electric field generated by an overhead line is mainly dependent on the voltage of the line and remains more or less constant once the overhead line is operational. The magnetic field will vary depending on the current flowing in the conductors. The EMFs produced by an overhead line will be highest directly under the line and will rapidly decrease at increasing distance from the line. The overhead line design influences the EMFs produced, so each of the proposed overhead line route modifications have been assessed separately.

4.2.2 Where a route has been modified and the clearance of multiple spans has changed, the span with the minimum clearance has been assessed. This will give the worst case for the route modifications or sections of route, with all other spans having lower EMFs.

4.2.3 Electricity assets operating at voltages of 132kV and lower that are present within the scheme, forming part of the distribution network, are specified in the Code of Practice on compliance (DECC, 2012a) as a type of equipment that is inherently compliant with Government exposure limits due to the design. These, therefore, do not need separate assessment. Evidence for demonstration of compliance with Government exposure guidelines for 132kV and lower overhead lines is maintained at:

http://www.emfs.info/compliance/public/

4.3 ZB route, towers 32-34

4.3.1 The ZB 275kV overhead line route modifications between towers 32 and 34 consist of replacing the existing tower 33 with a new taller tower and replacing the existing twin Zebra conductors with twin Totara conductors. The span will have a new minimum clearance of 16.89m.

4.3.2 Calculations were performed at the nominal voltage of 275kV and the pre-fault continuous rating of 987MVA at 1m above ground. The highest calculated EMFs produced by the overhead line modifications using the worst-case conditions are shown in Table 4.1. All calculations were performed in accordance with the conditions set out in the codes of practice.

4.4 ZB route, towers 18-27

4.4.1 The ZB 275kV overhead line route modifications between towers 18 and 27 consist of replacing eight existing towers with nine new towers and replacing the existing twin Zebra conductors with twin Totara conductors. The lowest span resulting from these modifications will have a new minimum clearance of 9.7m, where all other new spans have higher clearances resulting in lower EMFs.

4.4.2 Calculations were performed at the nominal voltage of 275kV and the pre-fault continuous rating of 987MVA at 1m above ground. The highest calculated EMFs produced by the overhead line modifications using the worst-case conditions are shown in Table 4.1. All calculations were performed in accordance with the conditions set out in the codes of practice.

4.5 YYJ route, towers 115-120

4.5.1 The YYJ 400kV overhead line route modifications between towers 115 and 120 consist of replacing four existing towers with four new towers. The new towers will be on a new alignment to allow for the Project. The lowest span resulting from these modifications will have a new minimum clearance of 8.72m, where all other new spans have higher clearances.

4.5.2 Calculations were performed at the nominal voltage of 400kV and the pre-fault continuous rating of 2,606MVA at 1m above ground. The highest calculated EMFs produced by the overhead line modifications using the worst-case conditions are shown in Table 4.1. All calculations were performed in accordance with the conditions set out in the codes of practice.

4.6 ZJ route, towers 10-15

4.6.1 The ZJ 400kV overhead line route modifications between towers 10 and 15 consist of replacing four existing towers with five new towers. The new towers will be on a new alignment to allow for the Project. The lowest span resulting from these modifications will have a new minimum clearance of 13.34m, where all other new spans have higher clearances.

4.6.2 Calculations were performed at the nominal voltage of 400kV and the pre-fault continuous rating of 2,606MVA at 1m above ground. The highest calculated EMFs produced by the overhead line modifications using the worst-case conditions are shown in Table 4.1. All calculations were performed in accordance with the conditions set out in the codes of practice.

4.7 4YN route, towers 45-50

4.7.1 The 4YN 400kV overhead line route modifications between towers 45 and 50 consist of replacing four existing towers with four new towers and replacing the existing quad Zebra conductors with twin Redwood conductors. The new towers will be on a new alignment to allow for the Project. The lowest span resulting from these modifications will have a new minimum clearance of 9.77m, where all other new spans have higher clearances.

4.7.2 Calculations were performed at the nominal voltage of 400kV and the pre-fault continuous rating of 2,606MVA at 1m above ground. The highest calculated EMFs produced by the overhead line modifications using the worst-case conditions are shown in Table 4.1. All calculations were performed in accordance with the conditions set out in the codes of practice.

Table 4.1 Calculated maximum EMFs from overhead line modifications

Route and tower spans	Conductor bundle	Minimum clearance of lowest span	Maximum electric field at nominal voltage (kV/m)	Maximum magnetic field at pre-fault continuous loading (μT)
ZB Towers 32-34	Twin Totara	16.89m	1.38	12.9
ZB Towers 18-27	Twin Totara	9.7m	3.94	34.4
YYJ Towers 115-120	Twin Matthew	8.72m	6.72	69.8
ZJ Towers 10-15	Twin Matthew	13.34m	3.10	33.6
4YN Towers 45-50	Twin Redwood	9.77m	6.40	61.7

4.7.3 The EMFs produced by the overhead lines decrease rapidly with distance from the overhead lines (Plate 4.1 and Plate 4.2).

Plate 4.1 Calculated electric fields from proposed modifications to the overhead line routes ZB, ZJ, YYJ, 4YN

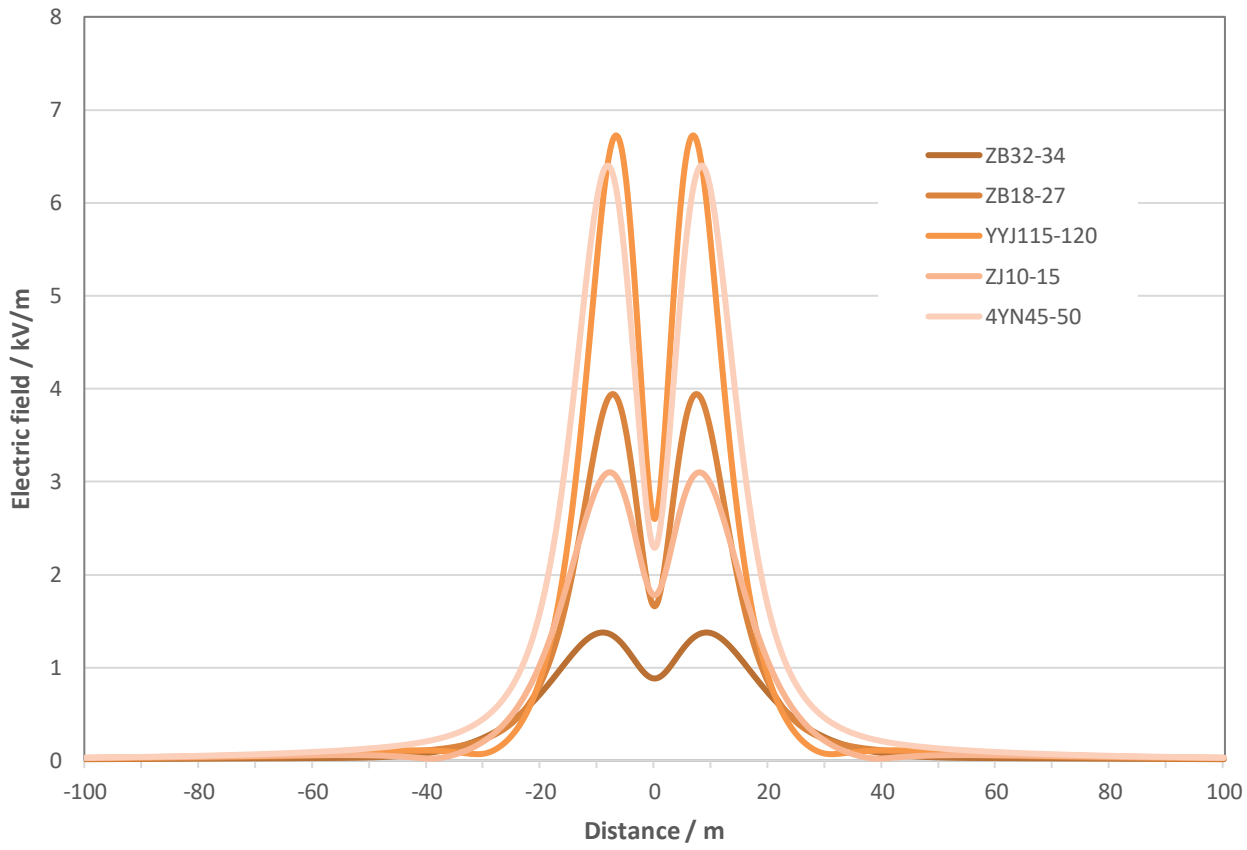
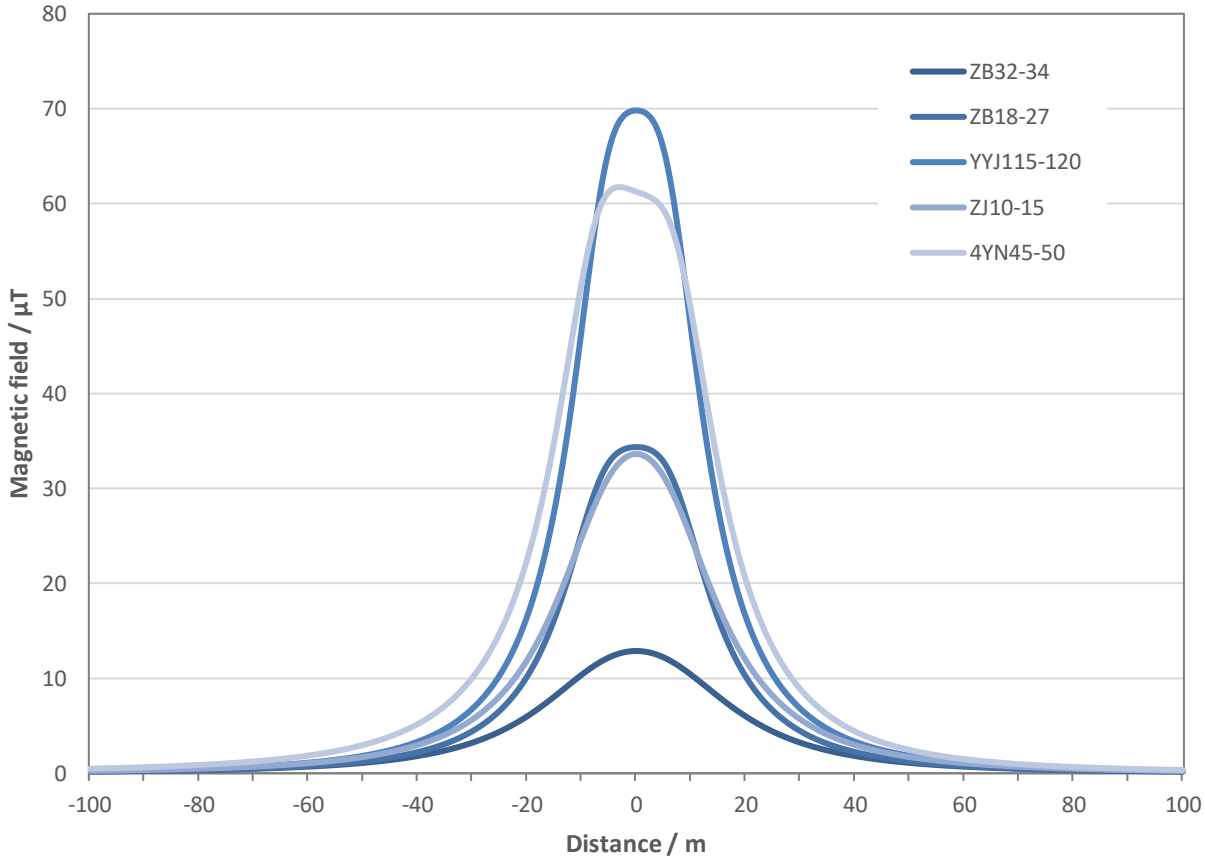


Plate 4.2 Calculated magnetic fields from proposed modifications to the overhead line routes ZB, ZJ, YYJ, 4YN



4.7.4 All the overhead line routes considered in this assessment are designed with transposed phasing, meaning that it is optimally phased as per the Code of Practice on optimum phasing (DECC, 2012b). Therefore, the two circuits are arranged to produce the greatest degree of cancellation between the magnetic fields produced by the two circuits and hence the lowest resultant magnetic field. This will remain the same after the proposed modifications.

4.7.5 The calculated EMFs for all proposed overhead line modifications comply fully with the Government exposure limits documented in Section 2.

4.8 Indirect effects

4.8.1 The public exposure guideline limits are set to protect against direct effects of EMF exposure. Compliance with the exposure limits ensures that no such direct effects of EMFs will occur. However, indirect effects such as interference to AIMDs, for example pacemakers, or microshocks could potentially occur at levels below these guidelines. The potential for these effects to occur is assessed below.

Active implantable medical devices

4.8.2 EMFs can affect AIMDs, such as pacemakers, insulin pumps and Implanted Cardiac Defibrillators (ICDs), if the external field strength exceeds the immunity of the device. EMFs can induce voltages in the body which, if high enough, can exceed the immunity of the device and temporarily affect its operation.

4.8.3 All modern AIMDs are required to be immune from interference from EMFs up to the ICNIRP General Public Reference Levels of 1999/519/EC (Council of the European Union, 1999) where the AIMD has been implanted and programmed in a standard manner. The ICNIRP General Public Reference levels at 50Hz are 100µT for magnetic fields and 5kV/m for electric fields. However, many AIMDs will have considerably higher immunity to external EMFs than the minimum requirements.

4.8.4 Specifically, the Active Implantable Medical Devices Directive (90/385/EEC)[1] includes the following provision:

'*Devices must be designed and manufactured in such a way as to remove or minimize as far as possible: …risks connected with reasonably foreseeable environmental conditions such as magnetic fields, external electrical influences…*'

4.8.5 The existing overhead lines are capable of producing electric fields in excess of the ICNIRP General Public Reference Levels (ICNIRP, 1998), but which remain lower than the public exposure limit. Therefore, in theory, some interference of AIMDs by EMFs could possibly occur. However, although theoretically capable of producing fields that exceed the public reference levels, neither the Medicines and Healthcare products Regulatory Agency (MHRA) or National Grid are aware of any instance of any electricity transmission infrastructure, including these particular overhead lines, interfering with a correctly fitted modern AIMD. The risk of any interference occurring is not significant in practice for the following reasons:

a. Manufacturers have to ensure that AIMDs are immune up to the General Public Reference Level, however many modern AIMDs will be immune to EMFs considerably in excess of these levels.

b. The maximum calculated EMFs provided in Table 4.1, Plate 4.1 and Plate 4.2 represent a worst-case scenario, chosen to demonstrate that exceeding the exposure guidelines is not possible. Typically, however, the overhead line will produce EMFs far lower than these levels for two reasons: the circuits are unlikely to operate at the maximum rating routinely, and a typical current on a day-to-day basis would be around 50% or less. In addition, the minimum design clearance of the overhead line conductors to ground is calculated using maximum rating conditions. Again, typically the conductors will be higher than this minimum design, therefore reducing the EMF, and the minimum clearance is found only in a limited area towards the middle of certain spans.

[1] Council Directive 90/385/EEC of 20 June 1990 on the approximation of the laws of the Member States relating to active implantable medical devices

4.8.6 Thus, there is confidence that, based on the absence of reported incidents and the typical EMF exposures that will occur on a daily basis, transmission assets would not interfere with AIMDs in practice. The risk of any interference occurring is assessed as being negligible and so does not constitute a significant effect.

4.8.7 This is confirmed in paragraph 2.10.7 of NPS EN-5 (DECC, 2011b), which states:

'*The Department of Health's Medicines and Healthcare Products Regulatory Agency (MHRA) does not consider that transmission line EMFs constitute a significant hazard to the operation of pacemakers*'.

Microshocks

4.8.8 Under high-voltage overhead lines conducting objects may become electrically charged if they are isolated from the earth. If this charged object is then touched by a person at a different potential, this charge is discharged to earth. Even when the person is very close to the object but not touching it, the voltage difference between the person and the object can be sufficient to cause the air to break down and a small spark discharge to occur. This can be perceived by the person and is known as a microshock.

4.8.9 The size of a microshock depends on the size of the electric field, the sizes of the objects concerned, how well grounded or insulated they are, meteorological conditions, and the sensitivity of the skin. All of these factors determine the severity of the perception, which can range from barely perceptible through to annoyance and, in some rare circumstances, even pain. Microshocks are similar to the static shocks that can occur by, for example, walking across a nylon carpet during dry weather. Microshocks have no known long-term health effects and any sensation is confined to the momentary spark discharge as contact is made or broken.

4.8.10 Microshocks are indirect effects and as such are not directly covered by quantitative limits that protect against direct effects of electric fields. The ICNIRP guidelines do have a cautionary reference level of 5kV/m, but limiting exposure to 5kV/m is not considered the most appropriate way of dealing with microshocks. Reducing electric fields by changes to the design is possible, but will usually result in taller towers, increasing the visual impact of the overhead line. As there is no threshold of electric field for preventing microshocks, the benefit of reducing the field to 5kV/m may be marginal. Rather than introducing an arbitrary limit, the Code of Practice on compliance (DECC, 2012a) states:

'*…there is a suite of measures that may be called upon in particular situations, including provision of information, earthing, and screening, alongside limiting the field which should be used to reduce the risk to the public of indirect effects. In some situations, there may be no reasonable way of eliminating indirect effects, for instance where erecting screening would obstruct the intended use of the land.*'

4.8.11 A separate Code of Practice on microshocks, developed jointly by industry and the DECC, is currently waiting for Ministerial approval. This follows the principles for managing microshocks quoted above but contains more details on the practical measures which can be taken.

4.8.12 The overhead line modifications have been demonstrated to comply with the Government exposure limits for electric fields, ensuring 9kV/m is not exceeded. Some areas under the modified overhead line spans would have electric fields which could potentially cause microshocks to occur if the correct set of circumstances exists. National Grid will ensure that if microshocks are reported these will be investigated and mitigated where appropriate.

5 Cumulative effects

5.1.1 EMFs can combine with the fields already present in the area from other sources such as distribution voltage lines and cables, which vary with time depending on electricity usage.

5.1.2 The modified overhead lines have each been assessed for compliance against Government guideline limits documented in NPS EN-5 (DECC, 2011b).

5.1.3 The way in which the fields combine with each other is complex. However, in this situation, where all the fields are significantly below guideline levels, it is not necessary to consider the details of this, as the combined field will also be below guideline levels. Therefore, the cumulative impact of all of the components of the proposed modifications is not significant.

5.1.4 It is National Grid's and the electricity industry's policy to ensure that all electrical assets comply with Government exposure limits and policies. As all of the overhead lines will comply with these exposure limits the cumulative impacts are not anticipated to be significant.

6 Mitigation

6.1.1 Since the proposed overhead line modifications have been demonstrated to comply with the current public exposure guidelines as detailed in NPS EN-5 (DECC, 2011b), no mitigation measures are necessary.

7 Conclusions

7.1.1 The modifications to existing overhead lines necessary to accommodate the Project are fully compliant with the current public exposure guidelines for EMFs documented in NPS EN-5 (DECC, 2011b). Therefore, there will be no significant EMF effects resulting from these proposed modifications.

7.1.2 Paragraph 2.10.6 of NPS EN-5 states, '*The balance of scientific evidence over several decades of research has not proven a causal link between EMFs and cancer or any other disease.*'

7.1.3 There is some scientific evidence of possible effects at lower levels at 50Hz. The electricity industry takes this evidence seriously and recognises that it can generate public concern. However, the evidence has been extensively reviewed, and the UK Government has not considered it appropriate to implement any restrictions or guidelines on the basis of this evidence. In addition to this, Government-adopted precautionary measures have been applied to further reduce EMFs.

7.1.4 The proposed overhead line modifications meet the Government adopted exposure limits as demonstrated using the principles set out in the DECC Code of Practice on compliance (DECC, 2012a).

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