The Voice of the Networks

Safety, Health and Environment

Phasing of UK Overhead Power Lines at 132 kV and Above

Report from Energy Networks Association to Government

In fulfilment of actions arising from the Stakeholder Advisory Group on ELF EMFs.

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Introduction

During the 2000s, the UK conducted an exercise to decide what precautionary policies should be adopted, in addition to the existing policy of compliance with exposure limits, in relation to power-frequency electric and magnetic fields (EMFs). The policies that were adopted were those recommended by the Stakeholder Advisory Group on EMFS (SAGE) and adopted by Government in a Written Ministerial Statement in 2009.

One of those precautionary policies concerns “optimum phasing”. “Phasing” is the order of connecting the phases of the two circuits of a double-circuit overhead line relative to each other. “Optimum” phasing is, broadly speaking, the phasing that produces the lowest magnetic fields to the sides of the line.

The details of the policy are set out in the Code of Practice “Optimum Phasing of high voltage double-circuit Power Lines A voluntary Code of Practice” published jointly by the Department of Energy and Climate Change with the Department of Health, the Energy Networks Association, the Welsh Assembly, the Scottish Executive and Northern Ireland Executive. The key provision of the policy is

“... the electricity industry will agree to:

- Design and construct new high voltage electric lines to include optimum phasing, unless this is unreasonable;
- Convert existing electric lines to optimum phasing when they are undergoing maintenance that involves replacing the conductors, unless this is unreasonable; and
- Where necessary, “unreasonable” will be interpreted in terms of the cost-benefit analysis presented in the SAGE First Interim Assessment (2007).”

The Code of Practice provides that industry will report to Government on the prevalence of optimum phasing at three-year intervals. This Report constitutes the first such report.

Methods, assumptions, and qualifications

The policy on phasing applies to overhead lines at 132 kV and above. In Northern Ireland, the equivalent voltage to 132 kV is 110 kV, and this Report includes 110 kV with 132 kV; future references to 132 kV should be read accordingly.

This report covers the member companies of the Energy Networks Association. ENA is not aware that there are yet any significant lengths of double-circuit overhead lines at 132 kV or above in the UK owned or operated by non-member companies. This situation could arise in future, however, and Government will then need to consider what arrangements it wishes to make in relation to phasing with such companies.

Phasing has been classified into four categories:

Optimum	The phasing is transposed and the direction of load flows in the two circuits is generally in the same direction; or The phasing is untransposed and the direction of load flows in the two circuits is generally in opposite directions
Not optimum	The phasing is untransposed and the direction of load flows in the two circuits is generally in the same direction; or The phasing is transposed and the direction of load flows in the two circuits is generally in opposite directions; or The phasing is neither transposed nor untransposed
Ambiguous	The relative direction of load flows on the two circuits is variable, or is expected to change over time, or is difficult to ascertain
Single circuit	Phasing does not apply

The default assumption has been that load flows will normally be in the same direction on both circuits, and therefore that the optimum phasing will be transposed, unless there are specific indications that other directions of load flow may apply.

Companies have not previously had to report on phasing, and it is not something on which data would naturally be held in readily accessible form for other purposes. Companies have therefore had to extract the data from other sources. This has been done using reasonable diligence, but in certain cases, assumptions have had to be made.

Results

The following table provides the results, expressed both as percentages of the total length of overhead line, but also as percentages of the length of double-circuit lines, i.e. excluding single circuits lines as these are not able to have optimum phasing applied.

The electricity industry often reports “circuit kilometres”. Phasing, which applies to one physical route carrying two circuits, is more naturally described by “route kilometres” which is the basis used in these results. But of course, within the three categories of phasing for double-circuit lines, this does not affect the percentages.

		Optimum	Not optimum	Ambiguous	Single circuit
132 kV	**% of total**	36.2	28.0	8.0	27.8
	% of double circuit	50.1	38.8	11.1	
275 & 400 kV	**% of total**	83.8	9.4	3.8	3.0
	% of double circuit	86.4	9.7	3.9	
total	**% of total**	56.3	20.2	6.2	17.3
	% of double circuit	68.1	24.4	7.6	

Commentary

As expected, the percentage of lines with optimum phasing is higher for 275 and 400 kV lines than for 132 kV lines. This is because the “supergrid” was constructed from the start in the 1950s with a policy of optimum phasing for system stability reasons, but no such general policy was applied to the earlier 132 kV system.

The previous estimate of these percentages was supplied as part of the SAGE process, and was that “Roughly 90% of the [National Grid] system has transposed phasing” and that “we estimate there is 12% [of the 132 kV system] - about 2000 km – that is not transposed but could be considered for conversion”. The former is now seen to be an accurate assessment, but for the 132 kV system, the existing prevalence of optimum phasing was overestimated. That estimate was produced on a much simpler basis than the present exercise, so is not directly comparable; the differences between those figures and these cannot be interpreted as actual changes over time. Future three-yearly reports will use the same, more accurate, basis as this present report so will allow changes over time to be observed.

As the provisions of the policy on phasing are applied, the percentage of double-circuit lines with optimum phasing should increase. However, this will be a slow process. In particular, two specific experiences in the three years since the policy came into effect have moderated expectations:

- In an instance when a part of the existing system was being reconfigured, which might be thought to provide the opportunity to implement optimum phasing, considerations of system stability, as provided for in the Code of Practice, over-rode the desire for optimum phasing; and
- The ability to convert an existing line to optimum phasing usually depends on there being sufficient clearances to reconfigure the order of the downleads from the terminal tower to the substation. In one specific case examined in detail, there was not sufficient clearance, and the cost of altering crossarms to achieve clearance would have been more than originally anticipated.

If these experiences turn out to be representative, opportunities for converting existing lines to optimum phasing may be less than hoped.

More detailed analysis of National Grid lines found that 10% of double-circuit lines do not currently have optimum phasing. Half of these, 5% of the total, are where three lines meet at a “T” point and optimum phasing is intrinsically not possible for all three. Of the remaining 5%, the phasing of some may be governed by considerations of system stability. This suggests that, for the UK, the effective limit on the percentage of double-circuit lines that can be optimally phased may not be much above 90%.

National Grid is considering the use of a new design of overhead line with the phases in a triangular array instead of the normal linear or nearly linear array. This will require adaptations of the definitions of “optimum” phasing as “transposed” and “untransposed” are not directly applicable. (The benefits of optimum phasing are less for triangular than for linear arrays, but the fields from the triangular array being considered are less to start with, so overall, there is no significant increase in fields.)

Next Report

ENA will provide the next report on phasing to Government in 2016 in accordance with the Code of Practice.